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BRITISH SURGICAL PRACTICE

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PHARYNGEAL DIVERTICULA

By JOHN MORLEY, Ch.M., F.R.C.S.
Emeritus Professor of Surgery, Manchester University; Surgeon, Manchester Royal Infirmary

1. DEFINITION

265.] The diverticula here described are pulsion diverticula formed in the posterior wall of the pharynx just above its junction with the oesophagus. The rare traction diverticula found lower down in the oesophagus and the pulsion diverticula in the supradiaphragmatic portion of the oesophagus are not considered. The existence of an anterior diverticulum described by the late Sir Arthur Hurst (1925) as situated 2 inches higher up on the anterior wall has been disproved. The appearance he described was due to barium lodging in the vallecula between the tongue and the epiglottis (Fig 1(a)).

(a) (b)

Fig 1—(a) Lateral view of pharyngeal pouch, also

The pouch we are discussing has been described, inaccurately, as oesophageal and, less

inaccurately, as pharyngo-oesophageal. Since the latter term is unduly long, and the term pharyngeal pouch is shorter and not open to misconstruction, it is preferred.

2. SURGICAL ANATOMY AND AETIOLOGY

On the posterior wall of the pharynx near its lower end there is a potential weak spot between the oblique fibres (thyropharyngeus) and the transverse fibres (cricopharyngeus) of the inferior constrictor muscle (Fig. 2). It is only in the event of some abnormal increase in intrapharyngeal tension that the

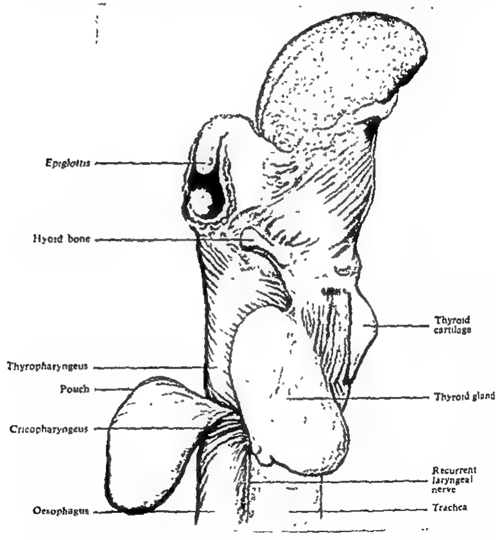

FIG 2 —Lateral view of a dissection of a pharyngeal pouch. (*After St. Clair Thomson and Negus*)

weak spot develops into an actual herniation. The causes of this intrapharyngeal tension, however, are not easy to explain. When a gross cause of obstruction to the lower part of the oesophagus is found, such as a fibrous stricture or pressure due to an intrathoracic goitre, the explanation is obvious. In the great majority of cases, however, no such factor is present, and we are forced to assume a spasm of the cricopharyngeus muscle as the cause of the increased tension during deglutition.

Obstruction of the oesophagus

Once it has started the pouch tends to increase by slow and imperceptible degrees with each act of deglutition. After the pouch has attained a certain size, it becomes, when filled with food, a source of pressure on the oesophageal lumen from behind and laterally, and gradually a vicious circle is established. The pouch, filled with food, makes deglutition more difficult, and hence food passes into the pouch more easily than into the oesophagus. At this stage serious interference with nutrition may result. *Loss of nutrition*

The pouch is a "false" one, in that its walls are not formed by all the coats of the pharynx, but only by its mucosa and submucosa herniated through the gap in the muscular coat posteriorly.

3. CLINICAL PICTURE

The condition is at least twice as common in men as in women, and occurs as a rule in middle age. Before the onset of real dysphagia there is often a sensation of something sticking in the throat which may excite an irritating cough that leads to some regurgitation of food. As the pouch enlarges slowly, the patient begins to notice both dysphagia and an obtrusive gurgling noise on swallowing. This latter is due to a mixture of fluid and air in the sac and often causes great distress to the patient and his friends, so that he dislikes to eat in public on account of the unpleasant noise. There are, at times, attacks of choking and coughing, leading to the ejection of solid particles of food that may have been taken many hours before. In some cases this is peculiarly troublesome when the patient lies down. *Early symptoms*

These symptoms may persist and cause considerable annoyance to the patient for many years without giving rise to dysphagia serious enough to interfere with nutrition. Sooner or later, however, oesophageal obstruction arises and progressive emaciation may result. In the larger pouches, and particularly in emaciated patients, there may be a visible swelling in the neck, usually on the left side, when the pouch is full of food. In such cases compression of the swelling causes immediate regurgitation of food into the mouth. *Dysphagia*

4. COMPLICATIONS

Inflammatory changes in and around the sac are rare but may occur in very large pouches. In one case the pouch had been present for over 10 years and held $1\frac{1}{2}$ pints of fluid, and the fundus was so adherent to the arch of the aorta that it tore during removal. *Adherence of fundus*

A more serious complication is the development of a squamous-cell carcinoma in the sac. I have reported two cases in which this had occurred. It is not easy to make a statistical estimate of the frequency of this complication, but enough cases have been reported to provide a strong argument against postponing surgical excision indefinitely.

5 SPECIAL AIDS TO DIAGNOSIS

Radiological examination after swallowing barium is as essential to an accurate diagnosis in this condition as it is in dysphagia from other causes. Skiagrams should be taken in the antero-posterior and in the lateral planes. The clearly defined rounded sac is quite characteristic (Fig. 1(b)). *Barium swallow*

Endoscopic examination is not necessary as a routine, but should be employed if there is any bleeding from the pharynx, or if the x-ray examination shows in the pouch a filling defect which might be due to a carcinoma.

6. DIFFERENTIAL DIAGNOSIS

(1) Carcinoma of the oesophagus

Carcinoma of the oesophagus is the commonest and most fatal of the causes of dysphagia; it should not be confused with a diverticulum, as the dysphagia caused by carcinoma is much more rapidly progressive, and is associated with anorexia, rapid emaciation and secondary anaemia. The barium swallow will almost invariably settle the diagnosis.

(2) Cardiospasm

Difficult differentiation

Cardiospasm (or achalasia of the oesophagus) may be much more difficult to differentiate from a diverticulum on clinical grounds alone, since in both conditions there may be a long history of dysphagia without great emaciation or anaemia. Here again x-ray examination settles the matter.

(3) Fibrous stricture

This may occur after the swallowing of a corrosive poison. A skiagram will differentiate such a stricture from a diverticulum.

(4) Intrathoracic goitre

This may be confused with a pouch. In a case reported by the author (1945) the patient's emaciation and dysphagia led to a suspicion of intrathoracic

FIG 3.—A large pharyngeal pouch containing food which was regarded as an intrathoracic goitre.

FIG. 4.—The same pouch as that shown in Fig. 3 filled with barium.

Examination of chest

goitre. X-ray examination of the chest showed a shadow that was regarded by the radiologist as an intrathoracic goitre. When the characteristic gurgling

only to be condemned. It was introduced by Goldmann in 1908 because of the risk of septic mediastinitis after primary excision, but this risk was due entirely to faulty technique. The two-stage operation is messy and tedious for both patient and surgeon, and is very liable to be followed by a fistula. If the patient is a very bad surgical risk, the preliminary gastrostomy described above provides a better and safer two-stage procedure.

Transverse collar incision

Endotracheal anaesthesia with either gas and oxygen, or cyclopropane, is the method of choice. It prevents any serious danger of inhalation of fluid contents that may be expressed from the sac into the pharynx during the operation. The sac is exposed by a transverse collar incision at the level of the cricoid cartilage. This gives as good an access as does the old incision along the anterior border of the left sternomastoid, and gives a better cosmetic result. When upper and lower flaps of skin and platysma have been raised and retracted the cervical fascia is incised along the anterior border of the left sternomastoid. Rarely the pouch projects to the right, and the approach may be made from that side. The infrahyoid muscles on the left side are then divided transversely. This exposes the left lobe of the thyroid gland (Fig. 5 (1)). The middle thyroid veins usually require to be divided and tied. The left lobe of the thyroid gland is then retracted mesially and the carotid sheath laterally, after which the left margin of the pouch comes into view. The pouch is seized with pile forceps, drawn up into the wound and dissected from the surrounding connective tissues until the neck is free and the junction of the pouch with the pharynx is thus clearly defined (Fig. 5 (2)). At this stage it is useful to have a full-sized oesophageal bougie passed down the oesophagus by the anaesthetist. It must be guided by the surgeon into the oesophagus, and passed very gently, as otherwise there is a danger that it may engage in the pouch and even penetrate its wall. Although not essential, this bougie helps to visualize the pharynx and is a safeguard against a too drastic excision of the pouch which might cause stenosis of the pharynx. Two narrow Schoemaker colectomy clamps are then applied across the neck of the sac, but not too near to its base. The sac is divided between them with the diathermy needle and removed (Fig. 5 (3)). A continuous inverting suture of 00 chromic gut is then passed over the remaining clamp (Fig. 5 (3a)). The clamp is slipped out and the suture drawn tight, invaginating the edges (Fig. 5 (3b)). The same suture is brought back as a second invaginating layer and tied at the end of this row to its other end. A few more points of interrupted catgut sutures are superimposed for greater security. It is essential that no mucosa is left pouting out of the suture lines or a fistula will be certain to occur. The invagination must be carried out with meticulous accuracy.

Thyroid gland exposed

Oesophageal bougie

Danger of a fistula

Some surgeons prefer fine interrupted silk sutures for the invagination of the base of the pouch (Sweet, 1947). The author prefers catgut because it is absorbed and would seem less likely on that account to form a sinus or fistula. Whenever a fistula does form, however, there has been some error in the method of suturing, and this, rather than the type of suture employed, is probably the cause of the failure.

Cause of failure

The operation is completed by suturing the divided infrahyoid muscles, leaving a small rubber dam drain (Fig. 5 (4)) down to the pharynx for 3 days. The platysma is then drawn together with a few stitches of fine catgut and the skin wound closed up to the drain with Kifa clips.

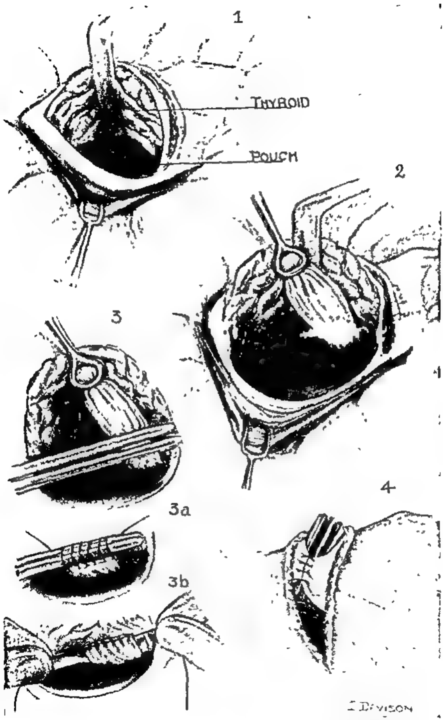

FIG 5.—Showing the stages of the operation (1) Exposure of the pouch; (2) the pouch dissected free, (3) clamps applied near base of pouch, (3a) continuous inverting suture applied over clamp, (3b) the suture pulled tight after removal of the clamp, (4) closure of the wound with insertion of a rubber dam drain.

(4) Post-operative management

Penicillin

A prophylactic course of penicillin is advisable. The first injection of 100,000 units is given intramuscularly before the patient goes to the theatre, and this dose is repeated at 8-hour intervals for 5 days. Continuous intravenous glucose-saline is given for the first 24 hours, during which nothing is given by the mouth, though frequent mouth-washes are encouraged. After 24 hours sterilized fluids may be swallowed slowly, but in adequate quantities. No solid food is given for 8–10 days.

9. RESULTS

No fatalities

The author has performed primary excision in 31 cases of pharyngeal pouch not complicated by carcinoma. There have been no deaths. In two very emaciated patients the operation was preceded by a gastrostomy in order to improve the patient's nutrition, and in two other cases with very large pouches, when the adequacy of the sutures was uncertain, a gastrostomy was performed at the time of the excision. Two patients developed a severe fistula in the neck which took 9 or 10 weeks to heal, and in three others there was slight suppuration. In the other 26 patients healing was by first intention and in all cases the clinical results have been good. The patients have lost the unpleasant gurgling in the throat when swallowing and have regained their normal weight. Small residual pouches are often found on subsequent radiological examination, but these do not appear to progress or give rise to symptoms.

Good clinical results

BIBLIOGRAPHY AND REFERENCES

Goldmann, E. E. (1908–9) *Beitr. klin. Chir.*, 61, 741.
Hurst, A F. (1925). *Guy's Hosp. Rep.*, 75, 367.
Lahey, F. H (1946). *Ann. Surg*, 124, 617.
Morley, J. (1945). *Brit. J. Surg.*, 33, 101.
Sweet, R. H. (1947). *Ann Surg.*, 125, 41.
Wilkie, D. P. D., and Hartley, J. N J. (1922) *Brit. J. Surg*, 10, 81.

[References to other titles are given under Pharyngeal Diverticula in the Index *Volume.*]

PHYSIOTHERAPY

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1. DEFINITION

266.] Physiotherapy is the application of physical agents and principles to pathological conditions for the purpose of promoting physiological response. With few exceptions it is an auxiliary to other therapeutic measures. There is a sharp division in the methods. In one form an external source of energy is applied and absorbed, in the other nothing is added, but latent body-energy is mobilized. The physical agents applied are electricity, radiations and heat. The principles involved are those of mechanics, as employed in massage and exercises. Full rehabilitation is not complete until the individual has effectively mobilized all his resources. Herein lies the indication for the use of the various forms of physiotherapy. The physiological response, however, varies not only with the extent or ability of the tissues to absorb and transform energy, but also with the form in which it is applied. The art of prescribing physiotherapy lies in combining the different forms in the correct order and in changing from one to the other as progress is, or is not, made.

2. PHYSIOTHERAPEUTIC METHODS

(1) Electrotherapy

In electrotherapy the unidirectional current (galvanic), the low-frequency current (sinusoidal and faradic), the high-frequency current (diathermy) and the radio-frequency current (short-wave diathermy) are used. Although it is convenient at this stage to retain the better-known terms, it must be realized

that the difference in the effects produced is the result of tissue reaction to difference in the behaviour of, and variations in, the electrical energy. Unidirectional current is energy at a low level with electron movement in one direction, resulting in molecular or ionic movement in the tissue fluids (ionization) and chemical changes, as shown by increased cellular activity, interchange of tissue fluids and the breaking-down of waste products. Variation in the current brings about additional tissue response. Thus, if the current is suddenly interrupted, muscle will contract (galvanic shock). If the strength and direction of the current are changed, much will depend upon the frequency of the variations. In faradism, with which the duration of applied energy is approximately one millisecond and the frequency of change is in the region of 50 per second, nerve-endings are stimulated with a current strength of low value which will cause neuro-muscular response. With increase in frequency and decrease in duration there will be cessation of the effect on nerve and muscle tissue, even if the current strength is increased.

Diathermy.—The type of current associated with this form of treatment is one in which frequency has been raised up to one million per second and the duration of the flow in either direction is so fractional as to be in the form of oscillations. As a result, the energy or the current strength can be applied at a considerably higher level. Ionic movement is negligible and, while the tissue fluids form a pathway for the current, the denser tissues, such as bone and fat, offer a resistance and heat is generated in accordance with Joule's law. (According to Joule's law, heat generated is in proportion to the square of the current strength, the time the current is flowing and the resistance.) By introducing heat within the tissues, new response is observed; this will be briefly stated later.

'oule's aw

(2) Irradiation therapy

The rays forming the electromagnetic spectrum are energy in motion or radiated, and they bring about still other physiological changes which are dependent upon the rate of movement of the electrons. *Gamma* radiations and x-radiations are at such a high level that they are essentially tissue destroyers. As the rate of electron movement decreases, wave-length increases and the destructive effects are lessened. Thus the shorter ultra-violet rays, those nearest the x-ray, are destructive to bacteria and, to a slight degree, to superficial tissues. The action of the longer ultra-violet rays is not bactericidal but largely biochemical, as is observed in the breaking-down of natural fat into fatty acid and cholesterol with the elaboration of vitamin D and in the splitting of amino acids, releasing a histamine-like substance. The former is the basis of the treatment of rickets, whereas the latter may explain the initiation of nerve reflexes which result in peripheral vasodilatation, stimulation of the endocrine glands, increase in the serum content of organic salts and decrease in sugar. Still longer wave-length radiations, that is, the visible and particularly the infra-red radiations, exert less chemical interchange and the transformation of their energy is manifested as heat, the physiological effect of which will now be considered.

ction of ltra-violet adiation

(3) Thermotherapy

Of all the physical agents employed in physiotherapy, heat is the most popular and most widely used. The physiological response varies according to the

method of application. Indirect methods, already referred to when considering electrical and radiant energy, produce special effects because of the energy transformation, as well as those effects due to heat, and in consequence are particularly suited for conditions in which deep heating is required. Direct methods provide superficial heating and their effectiveness is dependent upon the conductivity and toleration of the skin. Electrically heated pads are applied to the desired area. Baths of various kinds combine heat with other therapeutic agents. Water baths, as used in hydrotherapy, may have natural or artificial chemical substances in solution and the water may be aerated or agitated. Mud baths may incorporate iodine or radio-active substances. All of these contribute to the skin effect. Wax baths are a means of applying heat to irregular surfaces and retaining it for a considerable time within the tissues. As the wax cools, it forms a heat-insulating film and exerts a slight pressure. *Energy transformation*

The physiological effects of heat may be summarized in the following way.

(a) Maintenance of body temperature when the normal heat-regulating mechanism is disordered.

(b) Metabolism: the application of heat accelerates this physiological process.

(c) Increased cellular activity always results from increased energy absorption in the form of heat.

(d) Circulatory changes are shown by active hyperaemia, by a fall of blood-pressure and by leucocytosis.

Such methods as induce sweating must be avoided when there is pathological heat loss.

(4) Mechanical agents and kinesiology

This comprises massage and exercises and is the application of the principles of mechanics as well as the use of mechanical agents. Massage, which is the manipulation of the soft tissues, has been dealt with elsewhere (*see* After-care—Methods and Value of Massage, Vol. 1, p. 120). The object of exercises is muscle contraction and the stimulus is derived from the desire to obey a command or to perform a certain action. Latent energy is thereby transformed into work done, chemical action and heat production. The necessary energy expenditure is at a minimum if the action or exercise conforms to the laws of mechanics. If the pull of gravity is minimized, as with the use of suspension slings such as the Guthrie-Smith suspension apparatus, still less energy is needed. If gravity is augmented, as by the use of a weight and pulley, more work will have to be done Physiological response depends upon the movement, the manner in which it is done and whether the pull of gravity is aided or reduced. Exercises are designed to bring about joint movement as well as muscle contraction, but they also influence directly or indirectly the physiological activity of the whole of the body. Thus it is a physiological method of increasing respiratory exchange and lung capacity; the circulatory rate, as indicated by the output of the heart, is increased and glandular secretory activity is reduced. *The object of exercises*

3. TERMINOLOGY

Throughout the text the terms, galvanic, faradic, and sinusoidal currents will be used to indicate the type of current usually associated with these names.

l application of intensive doses of ultra-violet radiations sufficient to luce a marked active hyperaemia. The counter-irritant effect and the ation of a histamine-like substance are the modern counterpart of inunc- and blistering, with the advantage that the intensity and duration of on can be controlled.

) *Neuritis.*—When this is a true pathological entity, diathermy will nsify the pain; infra-red irradiation will relieve the local symptoms but have no influence on the underlying cause which must be removed, and results, as shown in atrophic muscle, dealt with. Neuralgia, on the other d, in which there are no histological changes, is often a manifestation of stitutional disturbance which may be emotional, occupational, rheumatic utritional. The commonest forms of neuralgia are brachial, sciatic, facial ntercostal. The general treatment with combined irradiation is of great ortance. Salicylate ionization will relieve the pain and, later, diathermy assist in rectifying local metabolism and circulatory changes. Exercises ıld be instituted only when postural defects have developed. After opera- procedure, now so popular in the treatment of sciatica, it has been erved that the most satisfactory results are obtained in cases in which t-operative physiotherapy on these lines has been instituted as soon as sible and has been continued even after the patient has resumed work. *Constitutional disturbance*

Arthritis.—Acute infective arthritis is best treated by local ultra-violet diation sufficient to produce superficial hyperaemia. It is believed by ny that diathermy may bring about or hasten generalized infection by genic organisms or the tubercle bacillus. Acute traumatic arthritis should reated on the lines suggested for synovitis. The treatment of rheumatoid ritis in the early stages is with infra-red irradiation to the joint and adism to the muscles involved. In the later stages ionization with histamine y produce dramatic results, but its prolonged use is to be deprecated. en there are hypertrophic or degenerative bone changes, short-wave thermy to the joint and faradism to the muscles are preferable. Exercises uld be instituted on a graduated scale in these later stages. In the obese, rfed or gouty subject, hydrotherapy is to be preferred to irradiation, and treatment is well worth while. Should gold injections be given, ultra- let irradiation should be used only with extreme caution in view of skin sitization. When operative procedure is contemplated, this should be ceded by 4–6 weeks' physiotherapy, and should include massage and adism to wasted muscles and re-educational exercises carried out with the nt immobilized by a splint. The object is to teach the patient how to walk h an arthrodesed joint and to develop the muscles which will be brought o play with the change in mechanization and posture. *Short-wave diathermy* *Precautions with gold injections* *Pre-operative measures*

Suppuration

xperience has shown that local chemotherapy, especially the use of phonamides and penicillin, although restricting the need for physio- rapy, has not displaced it. The combination of systemic chemotherapy and al phys'oth- ... er results than does either ... or general, contra-indicate ... ecome light-sensitized. It is ... in suitable cases is quicker, *Light sensitization*

the resulting scar tissue is more flexible, and muscle stiffness is less pronounced when physiotherapy is employed. The technique in most cases is similar and a few examples will be given.

(i) *Carbuncles.*—In the early stages the treatment is that of inflammation, but short-wave diathermy should be given within 24 hours of the appearance of pus formation and at least twice a day for periods of from 20 to 30 minutes. Spontaneous evacuation may occur. Whether or not this is desirable is a matter of surgical opinion, but in some cases it is inevitable and is a great relief to the patient. So long as pus is being evacuated, short-wave diathermy should be continued even after incision. As soon as the evacuation of pus ceases, treatment should be directed to healing and repair by means of local infra-red and ultra-violet irradiations, with movements to counteract stiffness.

Congestion

(ii) *Breast abscess.*—In the early stages of congestion, and when pus formation is in doubt, better results are obtained by local infra-red irradiation than by diathermy; many "abscesses" will resolve. When there is no doubt about the presence of pus, the use of short-wave diathermy will be a useful adjuvant to surgery.

(iii) *Suppurative adenitis.*—It is inadvisable in cervical adenitis to employ short-wave diathermy, and every endeavour should be made to bring about resolution or fibrosis of the glands. In the case of tuberculous adenitis it is definitely contra-indicated. Infra-red irradiation, followed by mild doses of ultra-violet irradiation, sufficient to produce a perceptible erythema, is the treatment in cervical adenitis, even when pus has collected, since experience has shown that it may resolve.

Abscess formation

In axillary adenitis, with abscess formation, short-wave diathermy is indicated. The after-treatment is the same as for carbuncles.

(iv) *Deep abscess.*—Short-wave diathermy has played a part in the successful treatment of several cases of abscess of the lung. Salpingitis, especially the chronic type, is another condition which responds well to this method. Suppurative osteomyelitis does not provide the necessary conditions for successful employment of short-wave effects.

(3) Ulceration

This term is used, rather with its clinical meaning than with pathological precision, to signify a group of conditions usually described as ulcers, a few examples of which will be given in order to illustrate the principles of treatment. Ultra-violet irradiation has a bactericidal action and yet stimulates tissue activity, whereas infra-red irradiation increases the circulation and encourages granulation. A sinusoidal current is directed along the limb or part of the body to stimulate local metabolism and nutrition, while assisting in the removal of waste products.

(i) *Bedsores.*—In the early stages before ulceration has occurred, the treatment will be that of an inflammatory condition.

Occurrence of infection

When degenerative changes and infection have occurred, as large an area as possible is irradiated with infra-red rays, thereby increasing the blood supply. The ulcerated area only will be exposed to ultra-violet radiation. In severe cases, in which there are "pockets", these are dealt with separately by using a quartz applicator inserted as far as the floor of the pocket. Treatment should be given twice daily and only a simple dry dressing should be applied.

(ii) *Trophic ulcers.*—The technique is similar but special attention is paid to indurated edges. These are given a destructive dose, using the short ultra-violet rays. The sinusoidal current is useful; for example, in the case of an ulcer on the leg, it is directed from the sole of the foot to the buttock or groin.

(iii) *Operation wounds.*—Ulceration of an operation wound which has broken down is treated in the same way as the bedsore, and the quartz applicator is inserted into the wound to enable flooding with the bactericidal short ultra-violet radiation and to stimulate granulation from below upwards. The wound is kept open in this way until it is healed to skin level. Incidentally this technique may be adopted for the treatment of any sinus or fistula occurring in soft tissue. In cases in which there is not immobilization, general exercises and combined irradiation are advantageous in debilitated patients.

(4) Atrophy

This will be limited to the local atrophy of muscles, resulting from interference with the nerve supply or from disuse or injury. Some reference has been made already to atrophy associated with arthritis and neuritis. General atrophy, or that due to constitutional disease, is beyond the scope of this article.

(i) *Nerve lesions.*—In the case of contusions, compression and involvement in surrounding inflammatory reaction following sprains and strains, the functioning of the motor pathway is temporarily suspended without structural damage. The classical examples are paralyses following soft-tissue injury—for instance, "crutch palsy". The object of treatment is to augment the natural physiological process. This is achieved by heat, and the best method is by diathermy, preferably short-wave diathermy, since no direct application to the skin is necessary, and deep heating is easier to obtain by the displacement current. Movement of the muscles, which is essential, should follow immediately. This can be done by surging the galvanic current; it is less uncomfortable than is the use of the interrupting current and contraction of the muscle fibres is caused without stimulation of the nerve. In this way the muscles involved are prevented from atrophying and little chance is given for inflammatory exudate to organize and form fibrous adhesions. As soon as tissue reaction has subsided, the splint can be removed to permit re-educational exercises and massage, graduated in the following order: with gravity assisting, then with gravity eliminated, against the resistance of gravity and, lastly, against resistance applied by the operator. Special exercises are arranged to suit the different nerves involved and the physiotherapist will be conversant with these. *"Crutch palsy"*

Bell's palsy is one of the commonest of these nerve lesions. The immediate use of infra-red irradiation and a surging unidirectional current will usually restore the condition to normal. That many will recover unaided is true, but it is difficult to recognize the favourable cases and to delay treatment materially affects the chance of recovery. *Bell's palsy*

In lower motor neurone lesions with structural interference to nerve impulse transmission, whether complete, partial or temporary, the object is to prevent or minimize muscle atrophy until the nerve has had a chance to recover. This is of particular importance in nerve suture. Diathermy will assist in

maintaining the effective blood supply and nutrition of muscle and nerve, and electrical stimulation with a surging galvanic current will assist in preserving muscle tone and in preventing adhesions. The affected muscles only must be stimulated individually, whereas if the electric bath is used, normal and opposing muscles will contract and pull on those paralysed, causing stretching, not only of the muscle fibres, but of newly sutured nerve. Exercise and movements of all joints which are immobilized should be started immediately after operation if the splint can be removed temporarily. When there are complications, such as chilblains, these should be treated with localized ultra-violet radiations.

(ii) *Disuse.*—As the motor pathway is not interrupted, the physiological method of inducing muscle action can be used by stimulating the nerve. In all cases of atrophy local nutrition is defective; heat, therefore, must be applied before muscle movement is initiated. *Inductive diathermy* An effective method is by inductive diathermy in which a current of radio-frequency oscillates along a rubber-protected wire coiled round the limb. This should be followed by neuro-muscular stimulation, using a slowly surged faradic current, in which the rest period is three times the duration of the contraction. After a few treatments the rate of contractions can be increased. Graduated exercises can be instituted at the same time, but mechanical devices should not be used until normal movements can be carried out without fatigue.

(5) Trauma

The foundations of physiotherapy were laid in the application of massage and exercises for the treatment of traumatic conditions. Owing to the advances in orthopaedic surgery on the one hand, and the expansion of physiotherapeutic methods on the other, non-traumatic surgical, medical and gynaecological conditions now absorb the energies of the physiotherapy department quite as much.

(i) *Fractures.*—Many orthopaedic surgeons hold to the view today that the need for physiotherapy varies inversely with the efficiency of the primary treatment of fractures. Little more than re-educative exercises are needed except for the associated conditions, some of which will be dealt with briefly. *Pre-reduction stage* In the pre-reduction stage, infra-red irradiation and light stroking massage will relieve spasm and pain. In cases in which the patient is confined to bed, diathermy and muscle stimulation will maintain muscle tone, ensure efficient circulation and prevent congestion. The treatment of stiffness of joints by infra-red irradiation and movements, carried out daily, will obviate the need for more drastic and prolonged after-treatment and do much to prevent arthritic changes.

(ii) *Ununited fractures.*—When the ununited fracture is not due to malposition or to the interposition of soft tissues, short-wave diathermy and the sinusoidal current will encourage efficient circulation and the formation of healthy callus. Combined general irradiation, in all cases, will stimulate the general metabolism and increase the serum content of calcium and phosphates. In cases of debility, anaemia and constitutional weakness, it is invaluable. The after-care of fracture cases has been dealt with in a previous

(iii) *Dislocation.*—The effects produced by a dislocation extend to all the structures entering into and surrounding the site of the injury. The soft tissues are bruised and lacerated, and short-wave diathermy will accelerate their repair after reduction and immobilization. The sinusoidal current will assist in the dispersal of effusion, but when this has subsided faradism should be applied to prevent the formation of adhesions between tendons, and to maintain muscle tone. In about a week or 10 days, the period varying with the severity and site of the dislocation, passive movements can be added, and these should be preceded by infra-red irradiation to minimize spasm. Opinions vary as to the time at which active movements should be instituted, but the institution of graduated exercises should not be delayed unduly. Muscle spasm before reduction can often be relieved by infra-red irradiation. If 20 minutes' exposure to a non-luminous source is given while preparations are being made, reduction will be easier and the need for anaesthesia avoided in the simpler cases.

Injuries to soft tissues

5. PRE-OPERATIVE AND POST-OPERATIVE APPLICATION

(1) Correctional treatment

In the presence of a serious pathological condition threatening life, attention to the major operative procedure must be predominant. The minor post-operative sequelae may, however, be distressing to the patient and incapacity may be unnecessarily prolonged. The institution of systematic treatment of these conditions considerably lessens the period of convalescence.

(i) *Respiratory complications.*—Modern methods of anaesthesia have reduced these very considerably, but when prolonged and deep anaesthesia is essential, much can be done by pre-operative breathing exercises, which can be resumed as soon as the patient is recovered sufficiently to take an intelligent interest in his condition. The involuntary respiratory action can be augmented by voluntary muscular control and the use of the abdominal muscles and movements of the thoracic portion of the spinal column. Thus the capacity of the lungs can be increased by depressing the diaphragm and arching the upper portion of the back. These exercises are also used to compensate for loss of lung area, as in pneumonectomy.

Pre-operative breathing exercises

(ii) *Back strain.*—Post-operative backache, a most common complaint after abdominal and pelvic operations, is due partly to postural strain during anaesthesia. Exercises should be instituted immediately after operation and before the patient is allowed to get up

(iii) *Development of deformities.*—Stiff joints can quickly develop in patients who are immobilized. Wrist-drop and foot-drop may result from pressure on the nerve by strapping on the operation table, by the stretching of muscles during unconsciousness, by constricting bed-clothes or bandages, or by the introduction of fluids subcutaneously. Infra-red irradiation, exercises and faradism should be instituted at the earliest moment.

Stiff joints

(iv) *Constipation.*—This can be prevented or relieved by abdominal massage and exercises, which often prevent habit formation in the matter of purgatives.

(v) *Incontinence.*—When this occurs after pelvic operations much can be done to re-establish control by electrical stimulation of the sphincters and perineal muscles, whether the condition is functional or organic, although complete

success is less likely in the latter case. Once control has been obtained, the patient can be taught suitable exercises, to be practised daily, which will considerably strengthen voluntary control.

All patients who are immobilized for several weeks should be given exercises before they are allowed to get out of bed. Flat-foot and spinal deformities which are due to weakened muscle can be prevented in this way. These are some of the post-operative conditions which can be prevented by the routine use of physiotherapy after operation.

(2) Supplementary treatment

When operative treatment is directed towards the correcting of a deformity, physiotherapy should be instituted, if possible, before the operation, so that the patient may learn beforehand what will be expected of him afterwards. Moreover, much can be done to remedy defective nutrition, atrophy and stiffness. The value of pre-operative physiotherapy in this direction has not been explored to the extent it might have been. After operation, for example, on contractures affecting the hand, the exercises the patient has learnt to do with the unaffected hand can be carried out on the affected one as soon as the wound is healed. These exercises must be preceded by the application of heat, and infra-red irradiation is better than "hot soaks" which render the tissues sodden and contribute nothing to their nutrition. In the more serious conditions, for example, when amputation is contemplated and a period of immobilization is inevitable, pre-operative attention to general health and fitness by means of combined general irradiation and exercises is of great value. During this period the exercises which will have to be instituted after the operation can be learnt, both by walking with the affected limb immobilized and by imitating suitable post-operative exercises demonstrated by the physiotherapist. As soon as possible after the operation exercises should be instituted even while the patient is confined to bed. The Guthrie-Smith suspension apparatus is most valuable for this purpose. Joints can be kept mobile and the whole musculature in good condition. Even at a very early stage stump exercises can be given by this means. Later, postural exercises and strenuous class and gymnasium work can be instituted before the artificial limb has been fitted. This can be done at a convalescent home which is suitably equipped for the purpose.

Postural exercises

6. SURGICAL TUBERCULOSIS

Although opinion is divided on the advisability of treating pulmonary infection with ultra-violet irradiation, there is considerable agreement as to its value in surgical tuberculosis. In all cases, combined general irradiation is essential and should be prolonged and intensive. The prognosis is best in cases in which marked pigmentation is secured. The local manifestations require individual attention.

Prognosis

(1) Lupus vulgaris

In lupus vulgaris the classical work of Finsen has not, as yet, been equalled. If the condition is diagnosed and treated in the early stages a cure can be effected simply by irradiation. In advanced cases, in which other methods have been tried, the progress of the disease can at least be brought under

control. Only in the case of previous x-ray treatment is ultra-violet irradiation contra-indicated. Finsen's technique is still the best, although the Kromayer lamp is as effective, and is simpler and less tedious to use. The dermatitis which sometimes follows aspiration or incision of tuberculous glands will also respond to local irradiation, but this should be of much less intensity.

(2) Laryngeal tuberculosis

The hypertrophic type responds best, according to Miller (1935). In lupus of the larynx and cords satisfactory results are obtained. To be effective the radiations must be applied direct to the lesions, as described above, using a suitable quartz applicator (Beaumont, 1933). *Direct application*

(3) Peritoneal tuberculosis

The serous and fibrinous forms respond well, as do glandular infections, both in children and adults. The local treatment is designed to produce a mild superficial erythema over the whole abdominal area. In epididymitis good results can be obtained when the local application is to the scrotal area.

(4) Tuberculosis of bones and joints

As auxiliary treatment to the customary therapeutic measures of rest, diet and fixation, both general and local irradiations are of great value (Gauvain, 1925). The affected area should be exposed to ultra-violet irradiation sufficient to produce a marked erythema. In the case of a sinus, occurring, for example, after osteomyelitis, the technique is to flood the cavity with a photo-sensitive dye, such as eosin or acriflavine, dipping into this a quartz applicator attached to a Kromayer lamp. Even without the latter technique, however, the method of flooding the cavity with direct ultra-violet irradiation is effective. *Ultra-violet irradiation*

REFERENCES

Beaumont, W. (1933) *Proc. R. Soc. Med.*, 26, 1321.
Gauvain, H. (1925). *Lancet*, 2, 10.
Miller, T G (1935) *Brit. med J.*, 2, 1254.

[References to other titles are given under Physiotherapy in the Index Volume.]

PHYSIQUE, BODY BUILD AND POSTURE

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1. DEFINITIONS

267.] Body build refers to the more permanent physical make-up of the body and particularly to size and configuration. It is determined mainly by the skeletal system, but superficial fat, musculature and the size of abdominal viscera contribute. The term physique is sometimes used loosely with a similar meaning, but it is convenient to use it with particular reference to the functional state. Posture describes the relative position of parts of the body which can be moved in relation to one another; the term is commonly used with referenc[illegible] form of [illegible] guished from those which are properly features of body build.

2. BODY BUILD

(1) General considerations

Variations in body build are hereditary to a substantial extent, that is, they are largely inherent in the fertilized ovum, but the circumstances of life, especially during the growth period, influence the way in which these hereditary qualities manifest themselves. *Heredity and environment*

Body build is but one aspect of the constitution; physique is another; and, indeed, performance capacity, the mode of reaction to pathological influences, and the chemical and nervous aspects of the constitution generally, are all primarily genetic, but they are affected by circumstances. Differences in body build are recognizable at birth. *The constitution*

(2) Body types

(a) *Endocrinological types*

Variations of body build suggest minor variations of endocrine function in spite of the absence of symptoms of recognizable derangement of any endocrine gland. The suggestion has been made that even the hereditary human variations might depend mainly upon differences of endocrine function; but it is now believed that these play only a small role in human behaviour. Minor non-pathological endocrine variations do occur, however, the most striking being those concerned with the sexual characteristics. A series of types may be compiled—acromegaloid, hypopituitary, hyperthyroid, pre-adolescent hypothyroid, suprarenal (hypocortical or hypophaeochrome types) and the types associated with Cushing's syndrome and hypogonadal states. The striking difference of body types which distinguishes the sexes is an example of phenotypical associations which arise at the hormonal level. Fatness or leanness, in general, is dependent upon the caloric value of the food, but there is an obtrusive genetic factor. Dwarfism occurs, apart from overt pathological causes, as an endocrinopathy and as a genetic feature.

(b) *Hippocratic types*

Empirical observation points to some association between body type and the incidence of certain pathological conditions. It was expressed in the Hippocratic distinction between the apoplectic and phthisic habitus and has been elaborated by many modern investigators. Certain general physiological and psychological differences have also been held to characterize the extreme types.

(c) *Kretschmer's types*

The best known of the Hippocratic body types are Kretschmer's pyknic and asthenic (or leptosomatic) types. The pyknic type, corresponding to the apoplectic type of Hippocrates, is stocky in build with a bulky trunk, short legs and strong muscles; there is a tendency to trunk adiposity and hirsutism, and the skeletal contours are pronounced. By contrast the asthenic type (leptosomatic) is of slender build, the trunk is small in girth, and the limbs are long and relatively amuscular.

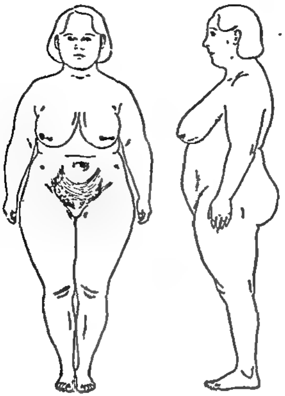
(d) *Sheldon's types*

Sheldon in 1940 provided an analysis of type which to some extent cuts across those of his predecessors. With a wealth of detail he described endomorphic, mesomorphic and ectomorphic types.

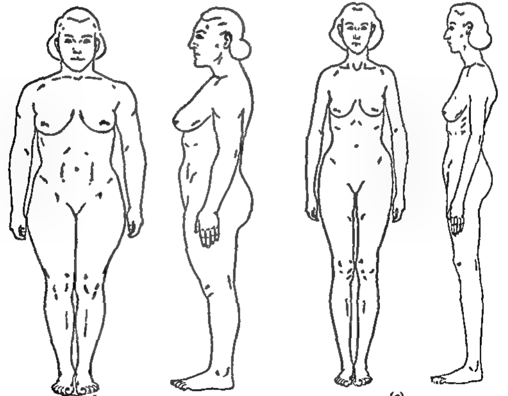
Sheldon's figures for the female are reproduced in Fig. 6, (a), (b) and (c).

The following are the chief features which characterize Sheldon's three extreme types in the male.

(i) *The endomorphic type.*—This type is characterized by a full round soft body, large abdomen and thorax (see Fig. 6 (a)); limbs tapering to their extremities, short neck, bones with thin cortex; high shoulders, flattened vertebral column; pseudo-breast fat deposit in the male, feminine thigh contours, feminine pattern of pubic hair, soft smooth skin, early baldness, hypoplastic penis, testis sometimes undescended. An association is claimed with a



(a)



(b) (c)

Fig 6.—Showing extremes of Sheldon's types in females. (a) Endomorphy. (b) Mesomorphy. (c) Ectomorphy.

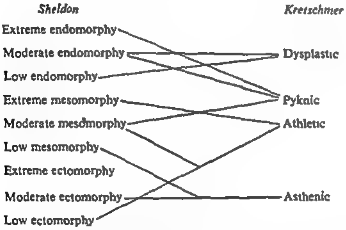
hard palate which is wide and rounded anteriorly, and a nose that is not prominent.

(ii) *The mesomorphic type.*—This type has characteristically large bones with prominent bony points and prominent muscle contours (*see* Fig. 6 (b)). The features are strong, the face large and the neck wide. The thorax is wide; the distal parts of the limbs are massive; the vertebral curves are best marked in the lumbar region; and the skin is coarse and tans readily.

(iii) *The ectomorphic type.*—Slender bones in this type are associated with inconspicuous thin soft muscles, short trunk, relatively long limbs and a long slender neck (*see* Fig. 6 (c)); the skin does not tan well but burns easily; the hair is fine; the penis is hyperplastic and the scrotum is pendulant. There is a small face with a receding chin, a head tending to dolichocephaly, inconspicuous brow ridges, and a hard palate which is narrow anteriorly. The skin is finely wrinkled and lacking in elasticity, and the chest is shallow with a narrow subcostal angle. The shoulders droop forward, there is a kypho-lordotic tendency, a weak abdominal wall sagging below and a neck thrust forward.

Comparison of types

Sheldon claims that the types retain their distinctive characteristics irrespective of the state of nutrition. The correspondence of Sheldon's with Kretschmer's types is shown approximately in the following diagram.



Sheldon analyses Kretschmer's pyknic type as a mixture of all types low in ectomorphy except extreme mesomorphs, which are included (along with ectomorphic mesomorphs) in Kretschmer's athletic types.

(e) *Pende's metabolic types*

Hippocratic types have been distinguished by Pende (1928). He describes three biotypes, hyperanabolic, orthometabolic and hyperkatabolic, based on Stefani's concept that cellular irritability represents a balance of function between the anabolic and katabolic processes of the cytoplasm; on this basis he attempted a correlation between physical appearances, temperament, psychic reactions, mental make-up and biochemical peculiarities. Thus the hyperanabolic is stocky and well covered, and exhibits slow physiological reactions and psychic responses and has adequate energy reserves, tends to

parasympatheticotonia and alkalosis, and there is a tendency to the analytical type of mind; the hyperkatabolic has more rapid reaction, an asthenic appearance and a tendency to "neurasthenia".

Pathological effects of "disharmony"

The combinations of features are thus given a physiological basis which in turn could be the outcome of genetic difference. According to Pende's theory a disharmony between the constitutional trend and changes that take place in the body leads to pathological manifestations. Thus health may be retained, despite overweight and alkalosis, in the hyperanabolic biotypes, whereas identical deviations in the slender hyperkatabolic type would produce morbid phenomena. On the other hand, the slender hyperkatabolic would stand up to loss of weight and a shift in the direction of acidosis better than the stocky hyperanabolic. On this view Pende's biotypes present a contrast to the endocrinological types, in which minor deviations towards the endocrinopathies have been supposed to indicate a greater susceptibility to the development of the appropriate endocrinopathy.

(3) The external environment

The external environment produces effects on general body build, though its effects on developmental epigenesis and on the physiological processes of the differentiated organs are comparatively unimportant. The human skeleton remains recognizably human, despite variations that arise from differing mechanical circumstances during the growth period (Appleton, 1934). Even deficiencies of diet, or acquired defects of the endocrine system, fail to obliterate its distinctive character as determined by the genetic make-up.

One of the earliest external environmental factors is provided in intra-uterine development by the action of maternal hormones, thus possibly arise the familial hypo-endocrine conditions as an apparently hereditary feature. It has been claimed (though not for man) that hormones derived from a developing twin modify development through an anastomosis which may develop between foetal blood-vessels in the placenta. In certain domestic animals the proper development of the external sex organs can be affected thus, with the production of the freemartin condition, namely, when hormones from a male foetus modify the sex development of the female twin. Recent work, however, has cast doubt on this interpretation.

3. PHYSIQUE

Physique is a functional aspect of the constitution. It measures performance ability and resistance to pathological conditions and mental strain. In this sense different physiques might prove to be, on the whole, best suited to different environmental conditions or different occupations, but there are few well-founded data from which definite statements can be made. Many features which may be properly described as "physique" in its more functional sense have already been discussed in dealing with body build. The factors which are concerned in the establishment of body type, apply equally to body function.

In the sense of physical efficiency and health physique, this is largely genetic, but is evidently affected by the circumstances of life, such as the diet. That the ability to resist disease is influenced by diet cannot be asserted with the

support of much evidence; opportunity for infection plays so important a part. Good visceral functions and the efficiency of the muscular apparatus depend upon adequate regular exercise and various environmental features.

Inheritance and environment

An important general feature in physique which deserves notice is the capacity for adjustment to exacting postural conditions.

Conspicuous differences in "normal" persons are found in the capacity to tolerate the standing position. This adjustment requires compensatory mechanisms of high efficiency if an adequate circulation is to be maintained in the vertical position, owing to the hindrance offered by gravity to the return of blood to the heart. Even in some people who are apparently normal, "orthostatic circulatory insufficiency" develops quickly. The upright position is tolerated least easily immediately after vigorous exercise, when the atmosphere is hot and humid, and when the position is maintained with little movement. If the vertical position is maintained passively, for example by suspension, it is tolerated still less well, and the simultaneous administration of alcohol, which causes further relaxation of the arterioles, hastens cerebral anaemia (hence the old custom of giving wine at crucifixions) Some of the fatigue effects of prolonged standing are attributed to anaemia of vital centres in the medulla, upon which depends the control of the cardiovascular system.

Orthostatic circulatory insufficiency

4. POSTURE

(1) Definition of good posture

It is now generally accepted that a good posture will be one in which the body functions best. This will differ for different people, especially for persons of different types of body build. It is recognized, moreover, that the attainment of identical posture for all persons is rendered impossible by the differing shapes of bones, and especially those variations of the long bones which are described as torsional.

Individual differences

There is reason to believe that the optimal posture for an individual will vary somewhat according to the circumstances and habits of life. On an empirical basis, different stances are recommended for those of heavy and those of slender body build. Even in young children the stocky type adopts a distinctive stance with backward carriage of the pelvis, in contrast to the slender type which tends to forward carriage (*see* p. 27).

For the purpose of a practical approach to the problem with the limited information at our disposal, a good posture is most satisfactorily defined as one which best resists disability, either as an immediate consequence or as a long-term result. A faulty posture is one which precipitates or predisposes to disability.

Absence of faults

Arbitrary standards have been proposed from time to time in the name of physical efficiency. They have, however, frequently needed modification. Their basis was largely empirical and in some respects they have been found to sow the seeds of disability; for example, the widely out-turned feet of a generation ago, which led to foot and back disabilities, and the more recently fashionable flat back which predisposes to backache. Aesthetic considerations have played a part, ostensibly in their own right. Furthermore, those who adopt arbitrary standards have sometimes come to believe that they have aesthetic arguments in their favour.

The empirical approach

The aesthetic aspect

(2) The development of postural habits

Idiosyncrasies of movement and posture appear from the time an infant begins to move about. Initially they are the outcome of the way in which the infant finds it possible successfully to achieve an object. They are based on the phenotypical make-up, principally depending upon the details of body structure (body builds differ already in infants) and of reflex pattern (which will not be considered further). New habits are developed continually; they come to diverge considerably from the "normal" when muscles are weak. Even if they are not weak the muscles may become tired, even in a strong child, and posture is affected in a manner similar to that caused by weakness. In children, unconscious imitation effects changes whereas, later, conscious imitation or disciplinary control is operative. Tall and short people develop different habits of standing for reasons that have a psychological as well as a mechanical basis. Apart from the postural differences that directly depend upon pathological conditions, profound alterations of posture may arise from some localized painful condition; thus, a corn on the toe may indirectly cause backache.

(3) Age changes

In infancy the child can scarcely be said to have a posture, so much is the position assumed determined mechanically by its environment. When a child first begins to move, its positions are so labile that comparisons with the stereotyped sitting, standing or lying positions of the adult have little value. When a formal standing posture becomes characteristic the principal difference from that of the adult consists in the pronounced concavity of the lumbar region; it remains a characteristic of the child till after it is 4 years old. Attempts to "correct" it have proved relatively unsuccessful. This well-developed concavity is sometimes retained in the adult, but such retention constitutes a fault of posture.

From the age at which movement starts, postural divergences worthy of calling faults (apart from pathological divergences) make their appearance. At first, they are mainly due to inadequate muscle action, but from later childhood onwards those living in "civilized conditions" develop faults which are the outcome of the prolonged maintenance of specific postures with inadequate employment of full ranges of movement.

(4) Postural idiosyncrasies and faults

"Faulty" posture has been blamed for an enormous variety of disabilities, extending not only to the locomotor apparatus but also to the viscera. Disorders of the alimentary functions, chronic prostatitis, and cardiac disturbances have all been thus attributed. There are, however, no good grounds, other than *a priori* assumptions, in favour of these comprehensive claims (Hellebrandt and his colleagues, 1942). Disorders of the locomotor apparatus itself, which have been conveniently distinguished as orthopaedic, are perhaps the only ones to be seriously considered in our present state of knowledge. It will be recalled that the most common cause of fatigue arising from long standing is probably a cerebral anaemia.

(a) Age of development of postural idiosyncrasies

The ages at which postural idiosyncrasies tend to develop most are stated below (some, such as kyphosis, tend to be earlier in girls).

Idiosyncrasy	*Age of occurrence*
Displaced toes with hallux valgus	4 years
Squinting knees	4–5 years
Pronated feet	4–5 years
Forward shoulders	10–12 years
Lumbar flexion, lateral flexion and rotation of the vertebral column	10–12 years
Kyphosis	14–16 years
Poking chin	14–16 years
Forward carriage	15–40 years

(b) Round shoulders

Two postural defects are included in this phrase: (1) a thoraco-cervical flexion and (2) forward shoulders. Correction of the forward shoulder is sometimes attempted without regard to the more common vertebral flexion. Forward shoulders lead to restriction of the capacity of the pectoralis major muscle for elongation. Misapplied efforts to stand upright then tend to result in a lumbar extension with or without elevation of the shoulders. This in turn may increase pelvic tilt and cause squinting knees and flat foot.

(c) Poking chin

This is the outcome of a thoraco-cervical flexion accompanied by atlanto-occipital extension as an "orthoptic" compensation (*see* p. 28). The semi-spinalis capitis and the longissimus cervicis shorten, the semispinalis cervicis and longissimus capitis lengthen.

(d) Squinting knees

Squinting knee consists in a medial rotation of the tibia as a whole, relative to the foot (Appleton, 1948). This necessarily involves movement at the sub-talar (subastragaloid) joint and thereby produces pronated foot (eversion at the subtalar and inversion at the midtarsal joint). The upper end of the tibia in "normal" persons faces forwards when the foot is directed a little laterally, with some individual variation due to difference of torsional form.

(e) Defective postures of the vertebral column

Certain general patterns are of special frequency, and are based on the inter-relationships of parts requisite for so complex a function as equilibrium in the standing position.

Wiles (1937) distinguished the following five varieties of abnormal spine; lumbar lordosis, sway back, flat back and two forms of round back (Types 1 and 2). Cyriax has discussed these types and, in addition, cervical lordosis and "forward neck". Knudsen recognized an evenly rounded back which appears to be allied to the round back, Type 1, of Wiles. Kyphosis and kypho-lordosis have been described by many authors.

(f) Forward and backward carriage of the pelvis

There is an intimate relationship between the form of the back and the attitude of the lower limbs (Appleton, 1944). The pelvis may show a forward or backward displacement relatively to the feet, known as "forward carriage" or "backward carriage" respectively (*see* anthropometric data, p. 32). Forward

carriage is effected by dorsiflexion of the ankle (with flexion of the knee in pronounced cases), backward carriage is effected by flexion of the knees (Fig. 7).

(i) *Forward carriage.*—When this is present there is a compensatory inclination of the vertebral column, which is effected in one of two ways: either (1) by an exaggeration of the lower part of the lumbar curve; or (2), more often, by a decreased forward tilt of the pelvis. The backward sway is, however, insufficient to maintain the line of gravity in its normal relationship to the feet (passing through the navicular bones); the line of gravity passes through a more anterior part of the foot and a greater proportion of the body-weight thus falls on the heads of the metatarsals. As an important effect the sacrospinalis is relieved from action. Two aetiological factors have been proposed, either of which is probably operative in producing the posture: (1) weakness of the sacrospinalis, and (2) upper thoracic kyphosis, which, tending to lower the outlook of the eyes below the horizontal, is compensated by the backward sway of the vertebral column (orthoptic compensation—Fick). Wiles's sway back and round back Type 2 are special cases of the forward carriage type of posture; in the former a localized lordosis is present, with diminished forward tilt of the pelvis, whereas in the round back there is increased tilt and lumbo-thoracic region flexion ("lumbar kyphosis"). The combination of sway back with forward carriage has been described as "over-carriage" by certain American investigators (Phelps and Kiphuth, 1932). It is the typical "bad" or "D" posture in the charts of the Children's Bureau of the United States Department of Labor, and in the Harvard classification of postures, it is the so-called *attitude ligamentaire* of the French authors, though this is a misleading appellation. In the grouping of the United States Department of Labor, this "bad" type is ascribed to slender children with a high pelvic tilt and a localized angulation in the lower lumbar region. The "bad" type thus recognized by many authorities is characterized by a long straightened region of variable length involving the upper lumbar and lower

Line of gravity

Aetiology

Associated features of the vertebral column

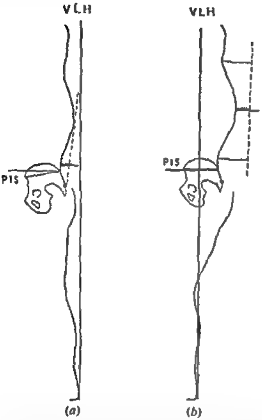


FIG 7.—Illustrating "forward carriage" and "backward carriage" respectively. VLH represents the vertical heel line. The sacral point is represented by a black dot. PIS—inclination of the plane of the iliac spines (*a*) Shows the method of measuring the depth of the lumbar concavity; (*b*) shows the method of measuring the depth of the lumbo-thoraco-cervical convexity

thoracic regions, ending above in a middle or upper thoracic local kyphosis and below in a lower or middle lumbar angulation (*see* Fig. 10 in Wiles's article, 1937). The extremely "upright" person commonly exhibits forward carriage or lumbar lordosis, or both.

(ii) *Backward carriage*.—In this posture the pelvis is displaced backwards relatively to the feet, but the line of gravity tends to be maintained in its usual *Line of gravity* relationship to the navicular bone by a compensatory flexion of both lumbar and thoracic regions; it may include a localized flexion in the lumbo-thoracic region (reverse curve). The degree of forward tilt of the pelvis shows no unusual feature; sometimes it is tilted more forwards, sometimes more back- *Vertebral column* wards, than average; there is often a cervical lordosis which provides orthoptic compensation. This position is seen in the evenly rounded back of Knudsen, and in Wiles's back, Type 1. It is allied to the bad posture for children of stocky build described in the United States Department of Labor's publication.

Goldthwait has emphasized the tendency for these lumbo-thoracic flexions to occur at different levels according to the body build: at Th.10–11 in heavy types (apparently a variant of Knudsen's evenly rounded back); at Th.11–12 in intermediate types; and at L.2–3 in slender types (apparently Wiles's round back, Type 2). Long lumbar curves have also been described, and are apparently closely related to the evenly rounded back. Localized thoracic convexities have also been described in the middle and upper thoracic regions (the latter a feature of sway back).

(5) Lack of postural variety

Of the various postures adopted by the body at different times, attention has been directed to three in particular, namely standing, sitting and lying. They are positions which are commonly adopted for considerable lengths of time and, for this reason, may have deleterious effects. The persistent employment of any given position tends to restrict the mobility of joints, and this restriction renders the adoption of other positions more difficult, more inefficient, and liable to cause rapid fatigue or disablement through pain. Movements, too *(for they are merely a succession of postures), are liable to become* clumsy and inefficient when the ranges of joint movement become limited; it is thus that ordinary walking and running movements tend to become altered in sedentary persons.

(*a*) *General effects*

If a muscle or a ligament is not fully elongated sufficiently regularly, it loses some of its capacity for extensibility in the course of time, and the range of movement at joints accordingly becomes restricted. Joint surfaces, moreover, *Joint movements* suffer changes; the portions of cartilage-covered surfaces which do not come into use undergo retrogressive changes at the margins.

A pronounced restriction of joint movement acquired by prolonged use of any one position makes it impossible to adopt other postures in a natural way Thus the sedentary person tends to adopt a modified stance; his requirements are that he must balance over his feet, that he must achieve this with his existing range of joint movements, that he shall make minimal demands on weak muscles, and that there shall be a semblance of a horizontal outlook

for the eyes. Commonly, he solves the problem by adopting a "forward carriage".

Bone form

The form assumed by a growing bone is directly influenced by postural habit. One feature of the bone which is thus greatly influenced is the torsional form of the long bones (Appleton, 1934). This in turn greatly affects the available range of postures. Such effects are produced only while growth is in progress and appear to be due to effects produced at the epiphyseal lines. Less striking changes (in healthy experimental animals) occur in the growth of both epiphyses and diaphyses; they produce such effects as genu valgum and genu varum.

If the habitual employment of wide ranges of movement is neglected, deleterious effects follow, mainly due to changes in muscles, ligaments and joint surfaces. When standing, there is complaint of rapid fatigue, especially in the feet, back or shoulders. The mechanisms by which pain develops in the back are dealt with in the article on Backache (Vol. 2, p. 1); similar principles apply to the foot. It may be stressed that important contributory causes consist in: (i) loss of capacity to attain some position, such as the standing one, in a "normal" manner, on account of loss of mobility at joints, especially that due to shortening of muscles; (ii) undue tension on ligaments; (iii) pressure on skin unaccustomed to pressure (for example, in the foot); or (iv) pressure between bony points (for example, in the vertebral column) Rheumatic conditions require to be considered as a further contributory cause of disability.

(*b*) *Special effects*

The principal special tendencies after prolonged use of a single posture are as follows.

Standing.—Lordosis (slackening of the rectus abdominis muscles), squinting knees (slackening of the lateral rotator muscles of the hip and the invertors of the foot).

Sitting.—Kyphosis, lumbar flattening; forward carriage and disablement of the anterior part of the foot when the standing position is adopted.

Lying.—Forward shoulders, inversion of the feet, pronated forearms, wryneck (in young children when the bed is against the wall).

(6) Methods of assessment

Postural deviations are most commonly assessed for the standing position. On account of the complexities of balance, comparatively minor changes in muscles and ligaments tend to produce wide deviations from the average stance; in the exacting mechanical conditions thus produced, disability is liable to show itself as a result of either muscular weakness or defective mobility.

The most convenient general means of assessment, when large numbers of persons have to be dealt with, is by means of a lateral photograph (or shadow) Since the midline of the back is not thus made visible, it is well to use an appliance which projects pointers backwards from various parts of the back for a distance of, say, 2 inches; the ends of the pointers show the form of the back. When photography is employed, skin markings are used to show the position of the tip of the mastoid process, acromial angle and "trochanteric point" (posterior superior tip of the greater trochanter) and the posterior end

of the tuberosity of the navicular bone. These points are determined as consistently and as accurately as possible. A plumb-line or grid is incorporated in the photograph to show the vertical. It is convenient to let the line pass either across the mastoid process or across the navicular bone.

Anthroposcopic assessment is still widely employed and provides a general impression of posture, either alone or in combination with other methods. Radiology is of service, especially for a precise study of the vertebral column.

Direct anthropometric measurement is required for the assessment of the forward tilt of the pelvis (best measured by Wiles's inclinometer) and is useful for many other features. The position of the line of gravity is an important feature for postural assessment in the standing position.

(a) Anthroposcopic assessment

The assessment is best made in the first place by inspection directed to the presence or absence of the more frequent faults. The head should be held high with "long" neck and the chin should not be "poking"; the shoulders should not be held forwards, and the inferior angles of the scapulae should not project; the cubital fossa should face medially and forwards; the curves of the vertebral column should not be too pronounced or too flattened (lordosis may be misjudged if the buttocks are bulky); there should not be any localized angularities or any pronounced lateral curvature; the pelvis should not be tilted too much forwards or too much backwards, and it should not be displaced too much forwards or backwards relative to the feet; the knees should not be squinting or hyperextended; the posterior aspect of the heel should be vertical. Some latitude is allowed for the direction in which the feet point, depending upon the torsional forms of the tibia and the femur; these have not yet been satisfactorily assessed in the living subject. In general the patellae should face forwards in the standing position and the feet may then be permitted to point in any direction between the straight forward position and a position pointing outwards and laterally at an angle of 20 degrees.

(b) Radiological assessment

This is of value for determination of the posture of individual intervertebral joints; data are available only for the lower lumbar region. Measurement is made on lateral skiagrams of the angles between the axes of adjacent vertebral bodies. A small angle represents a pronounced angularity.

	Ordinary angle	*Permissive range*	*Full ordinary variation*
Sacro-lumbar	140°	130°–155°	125°–160°
L 4 – L 5	160°	?	145°–175°

A sharp angle at the sacro-lumbar joint tends to be accompanied by straightening at the joint between L.4 and L.5, but some variation in the angle between L.4 and the sacrum nevertheless occurs (ordinary variation 110–135 degrees).

(c) Anthropometric assessment and permissive limits of variation

The permissive ranges given below are approximate, and may need revision in the light of a more extended knowledge of the relationship between disability and posture. They represent the limits beyond which there is some risk *Permissive ranges of variation*

of disability, usually in the back or foot (or both); the limits probably differ considerably in different persons.

(i) *The plumb line.*—This provides a very rough test of general posture. Passing across the mastoid process it goes approximately through the acromial angle, the trochanteric point (*see* p. 30) and the navicular bone of the foot. None of these points should lie more than 2 inches in front, or more than 1 inch behind, the navicular bone. In "heavy" subjects it is conventionally suggested that the head and pelvis should be farther back relatively to the feet than in those of slender (leptosomatic) body build.

Deviations are commonly due to a "poking chin", a forward position of the shoulder or a forward carriage of the pelvis. Little direct information is given regarding the posture of the vertebral column. Both the scapular and the pelvic postures can be better assessed by other means. The mastoid process should be not more than 2 inches in front or ½ inch behind the navicular bone. The ordinary range of variation is from −2 inches to 6 inches in front of the navicular bone; pronounced displacement of the mastoid process is generally due either to a thoraco-cervical flexion or to a dorsiflexion of the ankle.

(ii) *The pelvic tilt.*—This is measured by the inclination to the horizontal of a plane which passes through the anterior and posterior superior spines of the ilium; it is commonly measured by the Wiles inclinometer. Permissive range is from 4 to 10 degrees. Individual variation commonly ranges from −5 to 20 degrees.

An approximate assessment of pelvic tilt can be made by observation of the distance at which the anterior superior spine is situated below the level of the posterior superior spine. Ordinarily, it is about 1 inch lower, and this distance should not exceed 2 inches, at the other extreme the anterior spine should not be at the same level as, or higher than, the posterior spine.

(iii) *The pelvic carriage.*—This is measured by the distance of the position of the pelvis backwards or forwards relative to the feet. The upper end of the cleft of the buttocks ("sacral point") is, ordinarily, approximately in the same vertical plane as the posterior aspect of the heels. The permissive range lies between 2 inches in front of, and ½ inch behind, the vertical heel plane. It is conveniently measured by placing the subject at a suitable distance, say 3 inches, in front of the base of a height-stand or other narrow vertical column such as a door-post. The distance of the upper end of the cleft of the buttocks is measured from the height-stand and 3 inches is subtracted from the measurement obtained. It is necessary to allow these 3 inches in taking up the original position since in most subjects the buttocks will press against the height-stand if the heels are touching the base. The full ordinary range of variation for pelvic carriage is from −2 inches to 5 inches in front of the vertical heel plane.

(iv) *The head.*—This position is conveniently measured by the distance of its posterior aspect from the vertical heel plane (in the same manner as for pelvic carriage) Usually it is slightly in front of the vertical heel line. The permissive range is set between 0 and 2 inches in front of the heels. The full ordinary variation extends from − ½ inch to 4 inches.

(v) *The thorax.*—The distance is measured from the most posterior part of the thoracic convexity to the vertical heel line. Permissive and usual ranges of variation are the same as for the posterior aspect of the head.

(vi) *The scapulae.*—The medial margins of the two scapulae should not be less than 2 inches and not more than 5 inches apart. The full ordinary variation is from 2 inches to 7 inches.

(vii) *Curves of the vertebral column.*—(1) *The thoracic convexity* is assessed conveniently by the aid of an anthropometric caliper or similar instrument. The ends of two equal arms are placed on the deepest part of the cervical and lumbar concavities, the arms being long enough for the main rod of the instrument to clear the thoracic convexity. The distance between the convexity and the main rod is measured and subtracted from the length of the arms. The projection of the thorax behind the line joining the lumbar and cervical concavities is ordinarily 1½ inches. The permissive range is from 1 to 2 inches. The full ordinary variation is between ½ inch and 3½ inches. It has been stated that the maximum permissive flattening is shown by a string being straight and touching all vertebral spines when stretched from Th.1–L.5, but this is possibly an excessive flattening. (2) *The lumbar concavity* is measured similarly to the thoracic convexity, with the main rod of the instrument placed on the thoracic convexity and on the sacral point (the upper end of the cleft of the buttocks, fourth sacral vertebra). The ordinary depth of concavity is 1½ inches. The permissive range is from 1 to 1½ inches. The full ordinary range of variation extends from ½ inch to 2½ inches.

(viii) *Knees and feet.*—Only inspectional methods are available at present (*see below*).

(ix) *Line of gravity.*—This is measured by the partial weight method. Ordinarily the line passes through the navicular bone. The ordinary variation extends from 35 per cent to 60 per cent of the foot length in front of the heel (a range of about 2½ inches). The permissive range lies between 40 and 50 per cent of the total length of the foot in front of the heel. This allows a total latitude of 1 inch, from the posterior tip of the tuberosity of the navicular bone to a point 1 inch anterior to it.

(7) Prophylaxis

In general terms this consists in assuring sufficient strength in muscles by exercises combined with adequate nutrition. *Nutrition and exercise*

The primary cause of the deviation of posture must be diagnosed, since so many secondary effects generally occur. In particular, forward shoulders must be distinguished from thoraco-cervical flexion. *Diagnosis of cause*

Avoiding action is needed in regard to loss of mobility at joints. Individuals who spend much time in some given position should deliberately undertake activities in which they assume those other positions which have been neglected on account of the habit of life. *Mobility*

Particular cases may be considered.

(i) *The standing habit.*—Having regard to the statements made above, special attention should be given to the position of the knees and the tilt of the pelvis. The knees should not "squint" and the lumbar concavity should not be too great. *Special cases*

(ii) *The sitting habit.*—Extensor movements of the vertebral column are prophylactic. The manner of sitting requires attention. The pelvis should be placed far back in the seat so that (1) the thighs receive some support, and (2) an extension of the lumbar spine is encouraged.

(iii) *Lying.*—Movements should be practised by those confined to be These should be appropriate to the patient's condition, with a view to guar ing against the development of the contractures associated with continuo inversion and plantar flexion of the foot, pronation of the forearm and fo ward position of the shoulders.

Need for early recognition of faults

On account of the early age at which some postural faults begin to develo it is of the greatest importance that a significant postural deviation should l recognized early, and dealt with appropriately before muscles, ligamen and joint surfaces are affected. The very shapes, too, of the bones are affecte by mechanical conditions, but in the absence of specific data it must suffi to recall that large differences of bone form are produced by substanti postural deviation.

BIBLIOGRAPHY AND REFERENCES

Appleton, A. B. (1934). *Lancet*, 1, 451.
— (1944). *J. phys. Educ.*, 32, 5.
— (1948). *Hlth Educ. J.*, 6, 14.
Brobeck, J. R. (1946). *Physiol. Rev.*, 26, 541.
Bruch, H. (1939). *Amer. J. Dis. Child.*, 58, 1282.
Draper, G. (1924). *Human Constitution.* Philadelphia; Saunders.
Feigenbaum, J., and Howat, D. (1934). *J. clin. Invest.*, 13, 121.
Ford, E. B. (1942). *Genetics for Medical Students.* London; Methuen.
Gastineau, C. F., and Rynearson, E. H. (1947). *Ann. intern. Med.*, 27, 883.
Goldthwait, J. E. (1915). *Boston med. surg. J.*, 172, 881.
Goldzieher, M. A. (1939). *The Endocrine Glands.* New York; Appleton.
Hellebrandt, F. A., Riddle, K. S., and Fries, E C. (1942). *Physiol. Rev.*, 22, 88
— — Larsen, E. M., and Fries, E. C. (1942) *Physiol Rev.*, 22, 143
Klineberg, O., Asch, S. E., and Block, H. (1934). *Genet. Psychol. Monogr.*, 16, 145.
Kretschmer, E. (1944). *Körperbau und Charakter*, 17th ed. Berlin; Springer.
Kuhns, J. G. (1946). *Publ Hlth Nurse*, 38, 406.
Newburgh, L. H. (1942). *Arch. intern Med.*, 70, 1033.
— (1944). *Physiol. Rev.*, 24, 18.
Pende, N (1928). *Constitutional Inadequacies.* Philadelphia; Lea and Febiger
Phelps, W. M., and Kiphuth, R. J. H. (1932) *Postural Defects.* Springfield, Ill; Thomas.
Sheldon, W. H. (1940). *The Varieties of Human Physique.* New York; Harper.
Wiles, P. (1937). *Lancet*, 1, 911.
Wright, J. (1945). *Amer. J. Nurs.*, 45, 699.

[References to other titles are given under Physique, Body Build and Posture in the Index Volume.]

PITUITARY TUMOURS

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1. INTRODUCTION

268.] The subject of pituitary tumours would not be complete were descriptions limited to the adenomas, and it is necessary to review lesions arising primarily within the gland, and others encroaching upon it from structures in its immediate neighbourhood. In spite of the variety of lesions, including chiasmal injury, chiasmal arachnoiditis and aneurysms, as well as neoplasms which may be found in this vicinity, it is possible to arrive at pre-operative differentiation with reasonable accuracy. *Variety of lesions*

In the first place, it is important to appreciate the fact that all the tumours do not cause discoverable abnormalities in pituitary activity. Those which interfere with glandular secretion produce physical effects, sometimes due to excess of secretion, sometimes to diminution; the physical effects are often brought about by concurrent changes applicable to both these opposing actions. Our present knowledge of pituitary function indicates that its disturbance can be responsible for disorders of growth, metabolism and sexual function. Superimposed on these changes are troubles arising out of interference with adjacent structures when the tumour escapes the bounds of the

sella turcica. Of these anatomical structures the visual pathways are the most important.

Carcinoma

The cancerous tumours are to be suspected from the more rapid deterioration in the clinical state, with early implication of neighbouring structures, particularly the cranial nerves. In addition to the more rapid change in the patient's condition, disturbance of basal mechanisms such as the pulse rate, and undue sleepiness should act as warnings of the unusual nature of the tumour. Some of these tumours are found to extend over the greater part of the base of the brain, permeating in a subpial plane.

Sleepiness

It will be obvious that patients reach the neurosurgeon from several sources according to the complaint which calls for relief in any particular case, and the physician, the ophthalmologist, the endocrinologist, the gynaecologist, or even the genito-urinary expert may play a part in the selection.

Visual deterioration

Although the cases afford such a diversity of clinical problems it is because of visual deterioration or headache that surgical intervention is ordinarily required.

2. THE PITUITARY ADENOMAS

Basophilic adenomas

Cushing's syndrome

The simple tumours of the pituitary gland, or adenomas, are distinguished by their physical effects as well as by their pathological structure, and fall into three groups. One, the basophilic, is not of surgical import, for it is usually of small and sometimes even of microscopic dimensions. This tumour manifests its presence by the development of physical changes described as Cushing's syndrome. In this syndrome the patient gains weight, and develops a plethoric appearance, hirsuties, hyperglycaemia, vascular hypertension and polycythaemia, and there is gross striation of the abdomen and hips from stretching of the skin. It must be noted that this clinical state is not invariably due to adenomatous changes in the pituitary gland (*see* Adrenal Glands, Vol. 1, p. 101).

The other adenomas bring about abnormality of glandular action, and also, owing to their size, compress the visual pathways.

(1) Pathology

[Aff]inity for [sel]ective dyes

All the adenomas develop from the pars distalis of the pituitary, either from the pars anterior or the pars intermedia. They are to be recognized histologically mainly because of the affinity of the cellular components for selective dyes. The characteristic staining properties belong to certain granules within the protoplasm of the chromophil cells. Some of the granules stain with eosin, acid fuchsin or neutral dyes—so-called eosinophilic granules—whilst others take up the alum-haematoxylin and are basophilic. These granules are not present in the chromophobe type of growth.

(2) Types of adenoma

(*a*) *Chromophobe adenomas*

Reduction of hormonal secretion

By far the commonest form of adenoma is the chromophobe, which, although uncommon before the middle of the second decade, appears almost at any age thereafter. Clinical appearances arise from a reduction of hormonal secretion, with impoverishment of sexual function and metabolic inhibition. For instance, it is not unusual for a female patient to seek gynaecological aid for

persistent amenorrhoea, the true cause of which has sometimes not been revealed until vision is seriously impaired. Naturally, such a tumour forming in early life may prevent the initiation of the menses. Incidentally, operation is no guarantee of the re-institution of the menses and chances of pregnancy are remote, although not entirely abolished.

Loss of sexual libido is a constant feature, followed by testicular atrophy and a fading of the secondary sexual characteristics in the male subject. In view of the latter, hair distribution becomes sparse, and daily shaving is no longer necessary. Other changes to be observed are in the skin, which assumes a soft, silky or peach-like texture, together with a pallor reminiscent of that in pernicious anaemia. Often the scalp becomes exceptionally thin. Simultaneously metabolism is slowed down, with a resultant gain in weight and a reduction of the basic metabolic rate. Nevertheless, all patients do not attain gross dimensions; indeed, some of them in the later stages are wasted beyond measure (pituitary cachexia—Simmonds's disease). An asthenic state is usual, a low blood-pressure is almost a constant feature, and death may supervene even when the patient is being prepared for operation. The latter event is accounted for in some cases by haemorrhage into the tumour, but in other cases the cause of sudden death may not be discovered.

Loss of sexual libido

Slowing of metabolism

Low blood-pressure

Disturbances of function may be the only indication of a pituitary tumour for some years, because of the long period which must elapse before the tumour encroaches upon extrasellar structures. It may then invade the sphenoidal air sinus, or even the nasal passages, as shown by epistaxis, an event rarely seen nowadays, as the patient seeks treatment for other reasons before the eroding process has extended so far. The author has seen erosion through the optic foramen and the sphenoidal fissure with invasion of the orbit, and unilateral proptosis. This, of course, is a most unusual happening, but a minor degree of proptosis, unilateral or bilateral, is by no means unknown with new growths of the pituitary gland.

Cystic tumours are regularly encountered because degeneration occurs as the mass outgrows its blood supply. The contents then are sometimes of a mushy consistency likened to breaking-down blood clot, or at other times are yellow and transparent. Solid tumour tissue varies somewhat in consistency and colour, for it may be easily evacuated by a blunt spoon or may require some sharper dissection. The colour may be of a greyish or maroon hue.

Cystic tumours

Consistency of tumour tissue

Occasionally, a chromophobe adenoma develops in the pituitary stalk, and then the usual radiographic findings are absent. The case presents as a chiasmal syndrome with or without hypothalamic disturbances.

(*b*) *Chromophilic adenomas*

In contrast with the chromophobe tumour, the chromophilic adenoma is associated with excessive secretion of pituitary hormone, the influence of which is dependent in some measure on the age of the patient. In the earlier years of life excess of hormone leads to gigantism, but after the epiphyses have united the result is acromegaly with its characteristic alterations in bony structure and in the soft-tissues, which alterations are particularly marked in the head, the hands and the feet. Although the bones generally increase in girth, they become more porous, leading to a degree of collapse in the spinal axis with accentuated kyphosis. The tongue enlarges till it becomes enlarged

Excessive secretion of pituitary hormone

Acromegaly

in the mouth, with deep indentations made by the teeth; the scalp becomes hypertrophic and somewhat rugose, like the skin of a puppy's neck. Thus, the outward build gives a false impression of a powerful physique which masks the attendant weakness of the individual, whose asthenic tendencies make the surgical risk even greater than it is with a chromophobe tumour. It is of interest that patients with chromophilic tumours often suffer from excessive sweating of the hands and feet.

Deceptive appearance

Excessive sweating

(c) *Mixed adenomas*

It must not be inferred that the constitution of any pituitary adenoma is restricted in its structure to one or other of these cell types. As a matter of fact, mixed tumours are not unusual and form some of the largest tumours found. The clinical appearance in association therewith shows a confusion of signs, the resultant of both excessive and diminished hormonal secretion.

(3) Clinical features

(a) *Extrasellar extension*

Whereas clinical findings related to glandular activity identify an intrasellar adenoma it is the extension of any such tumour beyond the normal habitat that claims the attention of the neurosurgeon in particular. The commonest mode of expansion is by elevation and penetration of the diaphragma sellae, with encroachment on the visual pathways. Visual disturbance is thus the most important indication for operation.

Visual disturbance

Continued extension in an upward direction will approach the hypothalamus, disturbance of which will be shown by alteration of sugar metabolism, sleepiness and diabetes insipidus. Still further increase in bulk will ultimately lead to obstruction of the anterior end of the third ventricle and to hydrocephalus. The consequent rise in the general intracranial pressure is manifested by headache and vomiting. This extension may involve the interpeduncular region and later abut on the cerebral peduncles, giving signs of compression of the pyramidal tracts.

Headache and vomiting

Lateral spread compresses the temporal lobe, with uncinate epileptiform attacks if the tip of the lobe is involved, or a homonymous hemianoptic visual field defect if the lateral spread occurs in a more posterior direction to involve the optic tract or the optic radiations within the body of the temporal lobe. Generalized epilepsy would favour implication of the frontal lobe. It is possible for a pituitary adenoma to impair the function of the frontal lobe so that mental disturbances prevent the accurate assessment of visual impairment. Under these conditions the primary origin of the tumour may fail to be appreciated. Most neurosurgeons have encountered at operation a tumour within the substance of the frontal lobe and have excised it, to discover on section its origin from the pituitary gland.

Lateral spread

Generalized epilepsy

Another indication of lateral extension of the tumour is paralysis of the nerves to the ocular muscles. Diplopia, although no rarity, is not a common feature.

Diplopia

(b) *Visual changes*

The tumour, encroaching as it does on the optic chiasma from below, produces a visual field defect which commences in the upper temporal quadrants.

Naturally, the deformation of the fields will vary as the brunt of the pressure is directed to the optic nerve, the chiasma or the visual tract, since, as one would suppose, a tumour does not maintain a median plane as its axis of spread but, more often than not, deviates in its path to one or other side.

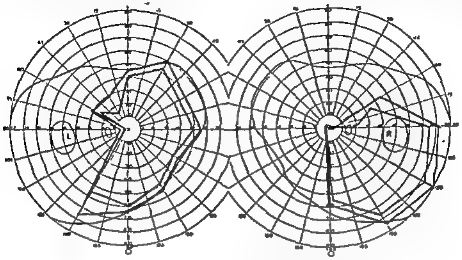

FIG 8 —Visual field showing left homonymous defect due to involvement of the right optic tract. Compare Fig 9, skiagram of same patient.

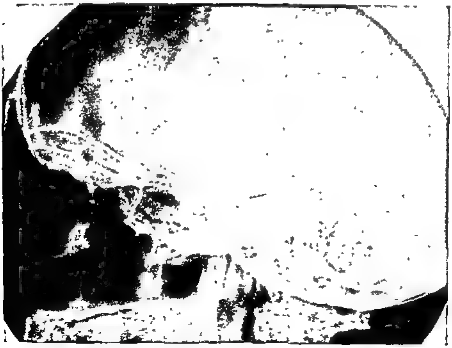

FIG 9 —Skiagram showing complete destruction of the pituitary fossa and disappearance of one clinoid process Compare Fig 8, perimetry charts of same patient.

Nevertheless, the typical field defect amounts to a bitemporal hemianopia (blinker fields) (Figs. 8 and 10). More careful study of visual fields, using a Bjerrum screen rather than perimetry as ordinarily practised, and using *Typical field defect*

coloured targets (red and green), sometimes reveals disturbance of visual perception which otherwise would be ignored. Islets of visual loss (scotomas) may be found within the visual field when perimetric outlines show no change,

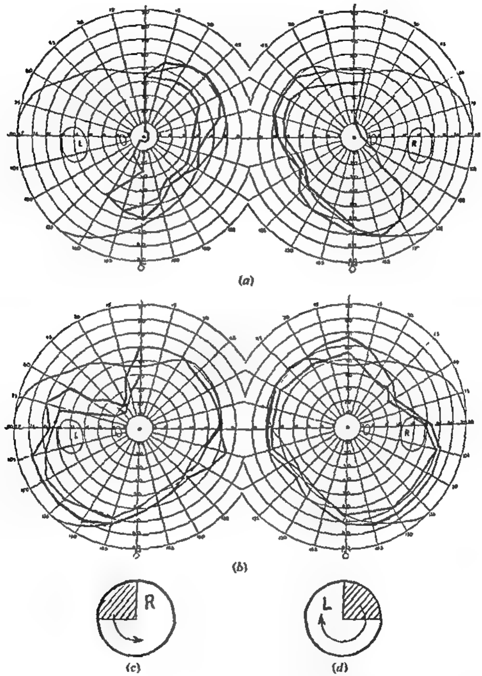

FIG 10.—(a) Perimetry charts showing visual defects before operation; (b) perimetry charts showing visual defects after operation; (c) and (d) diagrammatic representations of extension of visual defects.

and an enlargement of the blind spot may become apparent or an early notch in the upper temporal field may be disclosed. The visual defect extends like a shutter rotating about a central axis, the upper nasal quadrants usually being the last to suffer (Fig. 10).

It is possible for only one eye to be affected, or for one eye to reach the stage of blindness before the other eye is involved: this means direct pressure on the optic nerve. Should the pressure be applied to the optic tract, then it is an homonymous defect that ensues. *Pressure on optic nerve*

The visual fields are not the sole indications of interference with visual perception, for the visual acuity, too, is generally depressed. Inability to read is not a question purely of reduced visual acuity, it may well be due to depression of macular vision. Interference with the normal field does not mean complete disappearance of function immediately; it may be shown by diminished intensity of perception (a white object seems to be less white, or perhaps grey) in the affected area. *Diminished intensity of perception*

The story of visual impairment does not imply continued deterioration, for there may be an episode of serious impairment of vision followed by quite a satisfactory recovery. This is most significant because of its resemblance to the clinical picture of disseminated sclerosis, in which condition pallor of the optic disc may render the distinction from pituitary disease still more difficult if ophthalmological evidence is the only guide. *Resemblance to disseminated sclerosis*

(c) *Changes in the optic discs*

During the earlier stages there is no visible change in the optic discs. Subsequently the disc becomes pale, commencing on the temporal side, and the pallor gradually increases until the whole disc atrophies (primary optic atrophy). Throughout there is no correlation between the appearance of the disc and the state of visual perception. *Primary optic atrophy*

Papilloedema is rare in the pituitary adenoma, occurring only when the tumour is large enough to produce ventricular obstruction. It should warn the surgeon of the prospect of an unusually formidable surgical undertaking. *Papilloedema*

(d) *Significance of headache*

Headache has been mentioned as a symptom for which surgical intervention may prove to be necessary. The common bitemporal headache is probably related to increased tension on the diaphragma sellae, and its intensity varies from case to case. There is, however, a second type of headache due to internal hydrocephalus from blocking of the third ventricle This is the headache typical of raised intracranial pressure and it is associated with papilloedema. It is a rare complication of a pituitary adenoma when advice is sought early in the disease. *Increased tension on diaphragma sellae* *Internal hydrocephalus*

(e) *Radiographic changes*

The presence of a pituitary tumour is confirmed by the ballooned sella turcica seen on x-ray examination (Figs. 9 and 11) *Ballooned sella turcica*

With the globular form of the expanding tumour, the anterior and posterior clinoid processes become thinned and the former become widened. The anterior clinoids become rather pointed as a rule (Fig. 12), or may be bulbous, particularly in those with acromegaly. All tumours are not globular, and if they are lobulated corresponding changes are seen in the skiagrams. A spherical outline to the sella indicates a cystic tumour. Adenomas occasionally calcify, although calcific deposits are more likely to be found in association with other tumours, especially the suprasellar types (Fig. 13).

FIG. 11.—Skiagram showing enlargement of the sella turcica with thickening of the anterior clinoid processes.

FIG. 12.—Typical radiographic appearances in chromophobe adenoma, showing thinned and pointed anterior clinoid processes. Note the marked calcification of the pineal gland.

FIG. 13.—Skiagram showing calcification in a suprasellar tumour with moderate enlargement of the sella.

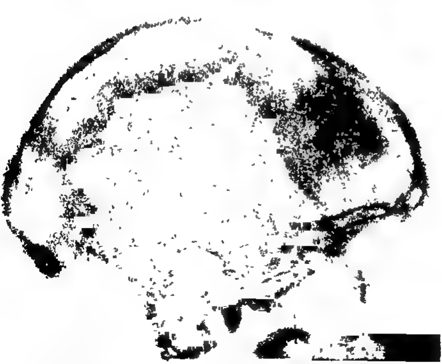

FIG. 14.—Skiagram showing distension of the cranial sutures and "hammer-marking" of the skull with disappearance of the posterior clinoid processes and hollowing out of the sella turcica—the picture of chronically raised intracranial pressure.

Acromegaly

In acromegaly, associated changes are seen in increased thickness of the calvarium, and enlarged frontal air sinuses. These points form important data of practical application in that the size of the osteoplastic flap will have to be fashioned accordingly, in order to avoid opening into the air sinuses. A large pituitary tumour may displace the pineal shadow and the surgeon must again make allowance in designing an adequate operative exposure.

"Hammer-marking"

Very rarely the general intracranial pressure is much increased. Should this arise in the earlier years, the cranial sutures may be distended; in other cases the appearance in the radiograph is of a coarse stippling, the so-called "hammer-marking" or "convolutional atrophy" (Fig. 14). These appearances, however, are more likely to occur in suprasellar tumours because of

FIG. 15.—Ventriculogram (same patient as in Fig 14) showing enormous distension of the anterior end of the third ventricle which is responsible for the erosion of the sella turcica.

their earlier formation and because these tumours are more prone to cause ventricular block with resultant hydrocephalus.

When hydrocephalus is caused by a block distal to the anterior end of the third ventricle, distension of the ventricle in front of the block gives rise to change in the sellar region. The posterior clinoid processes atrophy and the sella becomes hollowed out (Figs. 14 and 15). Radiographic appearances

produced in this way may be inconclusive in the differentiation between hydrocephalus and a pituitary tumour. So deceptive may appearances prove that it will be necessary to resort to ventriculography.

(*f*) *Lumbar puncture and cerebrospinal fluid analysis*

(i) *Lumbar puncture.*—The indiscriminate use of lumbar puncture in cases of intracranial tumour is to be deplored as many fatalities have been caused. On the other hand, controlled lumbar puncture sometimes proves a valuable source of information. When clinical evidence indicates a raised pressure one must be wary of accepting a low manometric estimation as being reliable. If the intracranial pressure is believed to be much increased, then lumbar puncture should be avoided. *Contra-indication*

(ii) *Cerebrospinal fluid analysis.*—Cerebrospinal fluid analysis can prove decisive in diagnosis. Increase in the total protein occurs in pituitary adenoma, suprasellar tumours, and meningioma and glioma of the optic chiasma, whereas the cerebrospinal fluid is usually normal in aneurysms which have not leaked, in epidermoid tumours and in chiasmal arachnoiditis.

Very occasionally the cell content of the cerebrospinal fluid is increased, but such a finding implies an infective basis or possibly the presence of a malignant tumour. An epidermoid cyst may, on occasion, be associated with an increased cell content of the cerebrospinal fluid. *Increased cell content*

(4) Differential diagnosis

A few points in differentiation between pituitary tumours and other space-occupying lesions occurring in the vicinity have been mentioned. Other suprasellar tumours occur—craniopharyngioma or adamantinoma and epidermoids—and it is necessary to add a few details about certain of the others.

First of all, it is most important to appreciate that the adenomas of the pituitary are the only tumours which produce symptoms related to excessive or diminished hormonal secretion Suprasellar cysts originating in Rathke's pouch certainly give rise to metabolic disorders and disturbance of growth (dystrophia adiposo-genitalis or Frohlich's disease), but not usually to the skin changes characterizing adenomatous growths. All tumours encroaching on the hypothalamus are liable to bring about disorders of sleep and diabetes insipidus. *Fröhlich's disease*

(*a*) *Meningioma*

Meningioma in the suprasellar region arises in the region of the tuberculum sellae or at the base of the anterior clinoid process. Suprasellar meningioma is very rare under 30 years of age. Patients who develop meningiomas are commonly persons with generalized neurofibromatous manifestations—pigmentary patches (*café au lait*) or cutaneous neurofibromas. Skiagrams often exhibit sclerosis of the bone at the site of the tumour, or there may be a visible localized hyperostosis. Loss of the sense of smell favours this diagnosis. *Age incidence* *Anosmia*

(*b*) *Glioma of the optic chiasma*

Glioma of the optic chiasma when extending through the optic canal enlarges that canal Skiagrams then show abnormality in the diameters of the optic foramina. The visual field may be more suggestive of an intrinsic lesion of the chiasma.

(c) Aneurysms

These are not invariably associated with vascular hypertension; in fact, most intracranial aneurysms appear to be of congenital nature. Hence the blood-pressure may afford little aid in differentiation, although the blood-pressure is usually low in cases of chromophobe or chromophil adenoma. Some aneurysms certainly show a typical ring-like calcific shadow (Albl's ring), but any doubt is settled by arteriography. Aneurysms do not produce disturbance of pituitary secretion and optic atrophy is rare. Perhaps an inferior defect of the visual fields is more in favour of a vascular lesion.

Albl's ring

(d) Chiasmal arachnoiditis

Chiasmal arachnoiditis has been publicized excessively. The experience of most neurosurgeons is limited to localized collections of cerebrospinal fluid which disperse suddenly during the operative approach. Masses of granulation tissue have been described, especially by French neurosurgeons. Lack of glandular disturbance, irregular deformation of the visual fields, the absence of radiographic change, and the presence of normal cerebrospinal fluid are all suggestive findings. Inability to fill the interpeduncular and chiasmatic cisterns on encephalography is a supplementary though negative form of evidence of obstruction in the appropriate region.

(e) Chiasmal injury

The author has had a case of chiasmal injury referred to him as a pituitary tumour because of the presence of a bitemporal hemianopia. The history of injury succeeded by static field defects in the absence of x-ray evidence of tumour formation was conclusive.

(f) Pituitary abscess

Occasionally at operation a cystic mass is exposed which, on aspiration, is found to contain inspissated pus-like material. The term "pituitary abscess" has been applied to the condition, but although some may be true abscesses, probably originating in sphenoidal sinus disease, others have been proved to be dermoid tumours, pituitary adenomas or cysts of Rathke's pouch. The infective cases are associated with increased cell content of the cerebrospinal fluid, which is also present in certain cases of dermoid and epidermoid tumours.

(5) Treatment

Surgical intervention is required to preserve vision or to relieve headache. The alternative is deep radiotherapy, but this is contra-indicated for cystic tumours and when there has been rapid deterioration of vision. Chromophilic tumours are more amenable to this form of treatment than is the chromophobe variety. Physical disability which precludes surgery or the refusal of operation are the main reasons for resorting to x-ray treatment alone. In the opinion of the author x-ray therapy should always supplement operation in patients with an adenomatous tumour.

Contra-indication to radiotherapy

Operation having been decided upon, there remains the choice of surgical approach. At first this was through the sphenoidal sinus, but once the trans-frontal route was practised the results proved to be so much better that the former method became more or less obsolete. Recently an attempt was made to revive the trans-sphenoidal method, but this did not produce any general

Choice of approach

return to it. The objection to the method lies in the impossibility of relieving pressure upon the visual pathways and, after all, relief from visual disturbance is the main reason for operation.

(*a*) *Transfrontal operation*

Through a unilateral incision within the hair line or a coronal incision, the scalp is turned down. A moderate-sized osteoplastic flap is fashioned to *Incision*

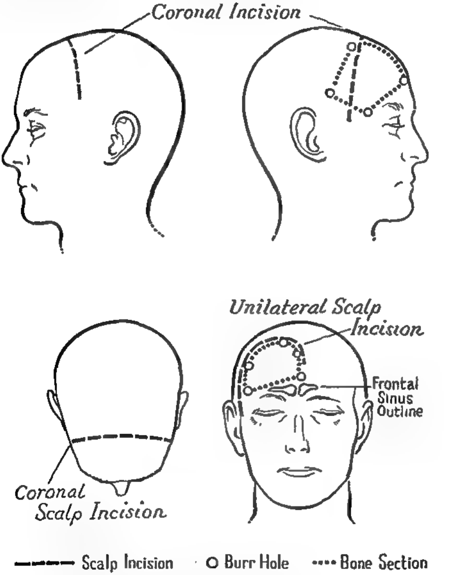

FIG 16.—Diagrams of the transfrontal operation showing types of scalp incision and form of the osteoplastic flap.

give maximal access to the inferior frontal region without involving the frontal air sinus (Fig. 16). Wherever possible it is reasonable to expose as limited a part of the frontal lobe as is practicable; therefore many neurosurgeons prefer to incise the dura close to the lesser wing of the sphenoid, after having elevated the brain covered by dura from off the orbital plate. The dural incision *Limited exposure of frontal lobe*

must provide free access to the anterior clinoid process and the anterior part of the sella turcica, together with structures within the immediate vicinity.

Recognition of olfactory tract

Recognition of the olfactory tract affords an excellent landmark on the way to the optic nerve. On exposure of the optic nerve, a wider field is brought into view by careful adjustment of brain retractors over intervening lintine,

Visualization of tumour

and a view is thus obtained of the tumour, which usually protrudes as a bluish or maroon coloured mass medial to the optic nerve. Exposure and

Needling and aspiration

definition of the protruding growth is followed by needling and aspiration. Aspiration not only affords evidence or otherwise of cystic degeneration, but also excludes the existence of a local aneurysm. Any capsular vessels likely to

Diathermy

hinder manipulations are coagulated with diathermy. An incision into the tumour capsule is made and the contents are evacuated by such means as the consistency of the mass requires—spoon, pituitary rongeurs or possibly the sucker. A subcapsular evacuation of the tissue is carried out to allow collapse of the capsule, and thus of complete freeing of the optic nerves and the optic chiasma. Portions of the capsule presenting can be excised but only with the utmost care, for damage to the anterior communicating artery or some branch

Avoidance of excessive retraction

vessel may result. Excessive retraction or any suggestion of distortion of the hypothalamus must be avoided, lest a hypothalamic syndrome of stupor, diabetes insipidus and perhaps hyperthermia be precipitated. Not all neuro-

Drainage

surgeons believe in drainage, but there would appear to be little added risk and much benefit from its use for 24 hours; certainly oozing blood is evacuated and any chance of increased hormone absorption is prevented After removal of retractors, steps are taken to avoid the formation of a post-operative clot—oozing from dural vessels is controlled by diathermy and the apposition of the dura is maintained by hitching sutures. The bone flap is replaced and the wound closed.

(*b*) *Trans-sphenoidal operation*

The trans-sphenoidal operation can help only as a decompressive measure

Risk of meningitis

The visual pathways cannot be seen owing to the risk of meningitis attendant on the necessary opening of the subarachnoid space. The result of this operation followed by deep x-ray therapy is less satisfactory than the transfrontal operation alone. When there is raised intracranial pressure produced by a ventricular block it may be necessary to remove part of the frontal lobe in order to gain access to the tumour. Furthermore, when a ventricular block cannot be relieved by a direct attack on the tumour mass, as in some suprasellar growths, drainage of the ventricle by means of a tube which is inserted into it through the parieto-occipital region, and which passes into the cisterna

Torkildsen's operation

magna through a subtentorial decompression (Torkildsen's operation) may afford relief (*see* Brain, Vol. 2, p. 438).

(6) Post-operative course and complications

The post-operative course of cases of pituitary growth is generally uneventful. Recovery of vision is immediate, as a rule, but if this does not occur the chance of improvement is poor.

Hypothalamic disturbance

Complications of operation are infrequent, although an acute hypothalamic disturbance may occur with somnolence or continued coma and a rising temperature (hyperthermia). The prognosis is bad and rigorous steps will be necessary if the patient's life is to be saved, and even then the chance is a very

poor one. Efforts to control the rising temperature are to be employed, such as air-conditioning and cold sponging. Help may be afforded by the administration of pituitrin into the ventricle. *Control of hyperthermia*

Polydipsia and polyuria are observed occasionally as the result of trauma to the hypothalamus. Pitressin drops given intranasally or the use of pituitary snuff will help. Injection of pituitrin may be required.

Persistent wasting and cachexia unrelieved by x-ray therapy may respond to treatment with testosterone. *Testosterone*

[References to other titles are given under Pituitary Tumours in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol. 9, p. 615.]

PLASTIC SURGERY—CORNEAL GRAFTING

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1. DEFINITION

269.] By the term corneal grafting is meant the removal of a portion of opaque cornea and its replacement by a portion of clear cornea. The graft should be autogenous or homogeneous. Attempts at transplanting the whole of the cornea (total keratoplasty) are unsatisfactory. Some success has been obtained by transplanting only the superficial layers of a limited area of cornea (circumscribed lamellar keratoplasty); the usual and most successful procedure, however, is to transplant a portion of the cornea involving its whole thickness (circumscribed penetrating keratoplasty).

Autogenous or homogeneous graft

Circumscribed penetrating keratoplasty

2. INDICATIONS FOR OPERATION

The desirability of corneal grafting is increased or reduced according to the density and extent of the corneal opacity, and the usefulness, or otherwise, of the other eye. In some eyes in which there is a localized opacity, an optical iridectomy may suffice. If the other eye possesses good vision it is usually not necessary to perform the operation.

Extensive and permanent corneal opacity can effectively be treated by corneal grafting unless this is precluded by some other pathological condition of the eye.

Suitability of the recipient eye

There should be good perception and projection of light indicating useful retinal function. The tension of the eye should be normal and there should be no suspicion of glaucoma. The ideal eye for corneal grafting exhibits an opaque cornea but no other gross departure from the normal anatomy of the anterior segment of the eyeball or of the conjunctiva and eyelids; opaque corneae, resulting from old interstitial keratitis, are usually very suitable.

Good retinal function essential

Adhesion of the iris to the cornea, or absence of the lens (aphakia), renders the eye less suitable for, but does not contra-indicate, operation.

Deformities of the eyelids, involving undue exposure of the cornea or producing inversion of the lid margins, must be corrected before any corneal graft is attempted.

The eye should be free from conjunctivitis, but in some cases a mild chronic conjunctivitis is a permanent feature, and operation may have to be performed after rendering the conjunctival sac as free as possible from pathogenic organisms. Other undesirable features are extreme photophobia or lacrimation, both of which make post-operative care very difficult. Children are not generally regarded as suitable subjects, although increasing amblyopia may make it desirable to operate at an early age.

Operation contra-indicated in children

It should also be remembered that although the eye may be suitable for corneal grafting, the patient's general condition may be unfavourable owing to disease, or nervous or mental disturbances.

3. PRELIMINARY OPERATIONS

It may be possible to convert an eye which is unsuitable for corneal grafting into one which is suitable or, at least, less unsuitable. This may imply preliminary operations for glaucoma, or to free a partially adherent iris, or to reduce excessive vascularization of the corneal surface.

The lids may be freed from adhesion to the eyeball by suitable plastic operations. Lashes rubbing on the cornea may be destroyed by electrolysis, and operations may be performed to relieve entropion or ectropion of the eyelids.

The donor eye

The usual source of donor material is an eye with a clear cornea, which has been removed on account of the presence of an intra-ocular tumour such as a sarcoma of the choroid. Eyes excised after injuries are usually not suitable on account of corneal damage. The cornea should be free from opacity in all its layers. Eyes removed *post mortem* may also be used. In such cases the eye should be removed as soon as possible after death—preferably during the first 12 hours; it should then be transported, in cold saline solution, to the operating theatre. It may be preserved in this solution (at from 2° to 4° C.) for some hours after removal; alternatively, it may be kept in a wide-mouthed bottle fitted with an air-tight stopper—this forming a moist chamber.

In this way an eye may be left for a day or so but, on the whole, the sooner the tissue is made use of the better. It is also possible to remove the graft direct from the cadaver without excising the eye. This should be done within 8–10 hours after death, the eye having been bathed previously with cold saline solution and a drop of penicillin solution instilled. The graft is placed in a phial containing cold saline solution and may be left in that way for a few hours, without deleterious effect, before being used. The graft becomes slightly swollen and cloudy, but rapidly regains its clarity when it is laid in place on the recipient eye.

The removal of the graft should be effected with due regard to asepsis, and should not be performed in the post-mortem room. The eye is first bathed with saline solution and a drop of proflavine is then instilled. It is important to choose a donor free from syphilis, general infective conditions, inflammatory conditions of the respiratory system and conjunctivitis.

Importance of aseptic technique

4. PRE-OPERATIVE MEDICATION

The patient is given a dose of a mixture comprising chloral hydrate and a bromide; this is followed by an injection of Omnopon. Hyoscine hydrobromide drops (½ per cent) are then instilled, and for half an hour before operation drops of a 4 per cent solution of cocaine hydrochloride are instilled as well as a drop of a 1 : 1,000 solution of adrenaline hydrochloride.

5. OPERATIVE TECHNIQUE

Technique employing two trephines

One technique will be described, involving the use of two trephines, slightly unequal in diameter and not mechanically driven. The smaller trephine is used for outlining the graft, the larger trephine for outlining the portion of opaque cornea to be removed. Two overlying sutures are used to hold the graft in place, and the margins of the graft and of the hole in the recipient cornea are sloping or shelving. Alternative methods involve the use of trephines of equal size, mechanical trephines, or flaps of conjunctiva to cover the graft in lieu of sutures. Castroviejo (1941) uses a square graft, held in place by an overlying continuous suture which crosses the graft four times.

Sloping margins of graft and cornea

(1) Preparation of the graft

The excised eye is placed on a stand and bathed with cold normal saline solution, or preferably citrated saline solution (70 cubic centimetres of a 0 9 per cent solution of sodium chloride together with 30 cubic centimetres of a 3 per cent solution of sodium citrate).

FIG. 17—Diagrammatic section through cornea and graft to illustrate shelving margins of graft and of the hole in the recipient cornea.

The graft is outlined with a trephine 4·4 millimetres in diameter; then, by tilting the trephine through 30 degrees, the anterior chamber is opened. A little citrated saline is applied from a dropper.

Removal of the graft is effected in a shelving manner (Fig. 17), with suitable blunt-pointed curved scissors It is then lifted on a spatula, placed with the *endothelial* surface uppermost in a black watch-glass containing citrated saline solution, and left undisturbed until applied to the donor eye.

(2) The recipient eye

Novocain by retrobulbar and subconjunctival injection

The eye is first bathed with saline solution, and 1 : 1,000 proflavine solution is then applied to the eye and the surrounding skin. Novocain (in 2 per cent solution) is administered by retrobulbar and subconjunctival injection.

A guiding silk suture, which serves for an assistant to steady the eye during the operation, is inserted, but not tied, at the lower limbus.

Citrated saline solution and a drop of adrenaline solution are then instilled. The central area of the cornea is outlined with a trephine 4 6 millimetres in diameter, care being taken not to penetrate the anterior chamber. Usually a thin red circle of blood shows up the trephine mark, but if the latter is not easily seen it may be stained with a drop of solution of fluorescein (½ per cent)

Insertion of vertical and horizontal sutures

Two sutures are now inserted (Fig. 18). To insert the first (the vertical suture) the surgeon stands at the head of the table; for the second (the horizontal suture) he stands at the side of the eye under operation. The ends of each suture are left free and about 10 centimetres long. The suture is of No 000 black silk on a special 14-millimetre eyeless needle. *It is advisable to soak the sutures in citrated saline solution before use.*

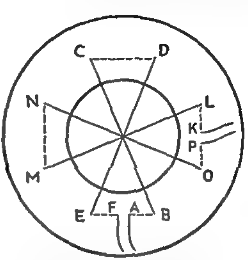

FIG. 18.—Diagram to illustrate arrangement of the two sutures which are inserted in the stroma of the cornea where indicated by a broken line, and lie on the anterior surface of the cornea and graft where indicated by a continuous line The vertical suture is ABCDEF. The horizontal suture is KLMNOP.

Position of suture knots

It will be noted that in the first suture ABCDEF, the portions *AB, CD, EF* are *intra-corneal*, whereas the loops BC, DE pass diametrically across the outlined circle. Similarly in the second suture, the portions KL, MN, OP are *intra-corneal, so that the knots* that will subsequently be tied at KP and at AF will not be able to move from their fixed position.

It is usually convenient to arrange that FA *shall be in the lower part* of the cornea and KP on the nasal side of the cornea.

Opening of anterior chamber

After retracting the loops of the second (horizontal) suture upwards and *of the first (vertical)* suture downwards, the trephine is applied, to deepen the outlined circle, and by tilting it to one side the anterior chamber is opened.

After instilling citrated saline solution and a drop of solution of adrenaline the opaque disc of cornea is gently seized with iris forceps and, by means of scissors, its removal is completed in a shelving manner.

The graft is now lifted from the black watch-glass with a spatula and inverted into place to fill the hole on the opaque cornea.

The loops of the vertical suture are lifted and laid in place over the graft and the slack taken up, but no knot is tied. The horizontal suture is similarly arranged in place over the graft. Each suture is then tied with three single knots. A drop of *penicillin solution is instilled*. A cartella shield, secured by adhesive plaster, is placed over the operated eye, this is covered in turn by a layer of gauze. No pad is placed on the affected eye, but a pad, secured by

of London

6. POST-OPERATIVE CARE

Removal of sutures

The eye is dressed daily and hyoscine hydrobromide drops and penicillin drops are instilled. Drops of Paroleine are also inserted at each dressing after the second day. The sutures are removed on the seventh day under local or

Pentothal anaesthesia, and for the following two weeks both eyes are covered with pads.

Protective glasses

After the third week the patient is allowed up and is given protective glasses; he continues to use Paroleine drops.

7. RESULTS OF TREATMENT

It is now established that the operation of corneal grafting is attended with considerable success in favourable cases. Filatov (1940) gives a figure of 52 per cent transparent grafts, and Castroviejo (1941) considers that in selected cases 90 per cent clear grafts may be obtained.

RESULTS OF 95 OPERATIONS ON 87 EYES

	Groups according to Degree of Opacity	Favourable Eyes: In favourable cases	Favourable Eyes: In unfavourable cases	Unfavourable Eyes due to: Extra-ocular conditions	Unfavourable Eyes due to: Intra-ocular conditions	Unfavourable Eyes due to: Extra-ocular and intra-ocular conditions	
Successes	1. Clinically transparent	18	—	—	3	1	62 = 65%
	2. Slight opacity in or behind the graft	12	2	2	6	1	
	3. Much opacity but less than original corneal opacity	8	2	2	3	2	
Failures	4. Much opacity equal to or more than original corneal opacity	5	2	10	13	1	33 = 35%
	5. Graft detached	—	—	—	1	—	
	6. Eye lost	—	—	—	1	—	

In favourable cases improvement may be expected in all but a small percentage. It is also possible to obtain clear grafts in some of the cases that are classified as unfavourable, and the table of results in the author's personal experience of 95 operations on 87 eyes is given to indicate the degree of success which may be expected when dealing with extensive corneal opacities in eyes of favourable or unfavourable types.

BIBLIOGRAPHY AND REFERENCES

Castroviejo, R. (1941) *Amer. J. Ophthal*, 24, 1, 139.
Filatov, V. P. (1940). In *Modern Trends in Ophthalmology*, 1st ed., p. 582. Ed. by Ridley, F., and Sorsby, A London; Butterworth.
Thomas, J. W. Tudor (1934). *Brit J. Ophthal.*, 18, 129.
— (1935). *Trans. ophthal. Soc. U.K*, 55, 373.
— (1938). *Ibid*, 57, 520.
— (1948) *Ibid.*, 67, 301.

[References to other titles are given under Plastic Surgery in the Index Volume]

PLEURA—DISEASES OF

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INTRODUCTION

270] The first suggestion of the pleural cavity in the embryo is seen when the primitive lung bud projects into the pericardio-peritoneal canal. The growing lung, covered by a thin layer of splanchnic mesoderm, invaginates this coelomic element, and finds room for its further expansion by splitting the body wall and forming a "secondary" pleural cavity which is lined by parietal mesoderm. *Development*

In utero the thorax is flexed and contracted, but on the first inspiration its walls expand and the spine straightens out as air is drawn into the previously collapsed lungs. There is thus a disproportionate increase in the capacity of the chest and this is referred to the potential pleural space, creating the sub-atmospheric or negative pressure of the cavity. The mechanism of pleural function is illustrated by placing two sheets of wet glass in contact They slide readily over each other and cannot be separated by force, but if air is admitted by inserting a knife edge between them, they part easily. *Pleural "pressure"*

The suction effect, equal to 5–8 cubic centimetres of water, holds the elastic lung against the inner surface of the thoracic cage, and the close contact of the smooth, moist, internal surfaces of the pleura is constantly maintained unless interrupted by the introduction of fluid or air. In health the negative or subatmospheric pressures on the two sides are reciprocally balanced, but if the layers of one pleura are separated, the lung of that side fails to expand to its full extent and the equilibrium of the mediastinum is disturbed.

In chest surgery the physiological and mechanical functions of the pleura are as fundamentally important as is their pathology. The bony framework of the thorax has proved to be a smaller barrier to the surgeon than is this thin membrane. The pleura is a thin sero-elastic membrane, capable of secretion and absorption, continuous over the whole of the lung surface and reflected without break of continuity from the hilum over the mediastinum, diaphragm and interior of the chest wall. The visceral pleura is extremely thin, but is so firmly attached that it cannot be removed without injuring the actual lung surface. *Structure and physiology*

The parietal pleura is more loosely attached; it lies on the endothoracic fascia in which plane it can be stripped off the chest wall—a feature used in the operation of extrapleural pneumothorax. A similar and even more

tenuous attachment exists over the mediastinum and sternocostal region, but over the diaphragm the membrane is firmly adherent.

Pathology

The reaction of the pleura to injury or disease is principally exudative, accompanied by desquamation of cells, oedema and fibrin formation. An active effusion has a specific gravity of 1·020 or more, and has a protein content of over 4 grammes per cent, with a variable amount of fibrin which leads to some clotting of the fluid if the latter is withdrawn. By comparison, the transudate of cardiac or renal disease has a lower specific gravity and a protein figure of 1·8 grammes per cent or less, without any fibrinogen. The important practical point about pleural irritation is that it reacts by exudation rather than by a plastic inflammation, so that localization of the process is delayed—a delay to which the continuous movements of the chest and heart are also contributory. The pleural membrane, however, has a considerable, if variable, endowment of defence against infection and, if not coated by a non-absorbent fibrin layer, can absorb fluid readily once the irritative factor is removed. Some degree of pleural adhesion is inevitable after pathological changes, the extent and character varying between wide limits.

Response to irritation

Thinness of pleura

The parietal pleura against the chest wall and diaphragm alone is provided with pain fibres which lie with the lymphatics just outside the serous layer. The delicate nature of the virgin pleura renders it peculiarly prone to injury once the supporting structure is removed; suture of the pleura is thus impracticable unless the adjacent tissues are included, but there is a power of rapid regeneration which prevents raw areas from being exposed for long.

PART I
PNEUMOTHORAX; PLEURISY; HAEMOTHORAX

1. OPEN PNEUMOTHORAX

Surgery of the thorax depends largely upon the management of the pneumothorax which is produced by incision through the parietal pleura. With an open pneumothorax there is collapse of the lung, which moves paradoxically on respiration; the balance of the mediastinum is upset and mediastinal flutter is provoked with consequent circulatory interference and distress (Fig. 19). At the same time the phenomenon of "*Pendel-Luft*", by which *Mechanics*

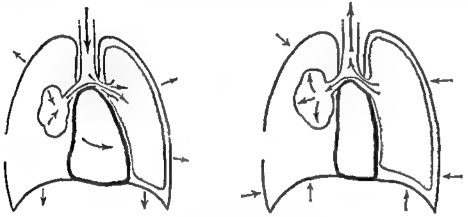


FIG. 19.—Open pneumothorax. The changes occurring during inspiration (left) and expiration are illustrated.

gaseous exchange in the good lung is interfered with, results in an accumulation of carbon dioxide and a poor intake of oxygen in the sound lung.

An open pneumothorax is a considerable strain on any person for, even though the vital capacity of a healthy individual is anything from six to eight times that of the tidal air, a pneumothorax must obviously lower that capacity. If then there is any added pathological condition, the vital capacity may fall below that of the tidal air with consequent asphyxia. The success of modern thoracic anaesthesia depends upon ability to control the open pneumothorax so as to allow adequate ventilation and oxygenation in the unaffected lung, with stability of the mediastinum and limited or controlled movement of the collapsed lung. The methods by which these criteria are attained are elaborate and require considerable skill in administration. *Disability*

2. CLOSED PNEUMOTHORAX

A closed pneumothorax results in a collapse of the lung corresponding to the amount of enclosed air; a tension or pressure pneumothorax, however, in which the incoming air is precluded from escape, collapses the lung completely and pushes the mediastinum to the sound side (Fig. 20). Here the paradoxical movements of an open pneumothorax are not obvious, but marked respiratory and circulatory embarrassment is occasioned if the condition is not relieved. *Tension*

The control of a closed pneumothorax or of one in which tension is developing is based on aspiration of the enclosed air as often as the conditions demand.

Artificial pneumothorax The commonest form of closed pneumothorax is ...

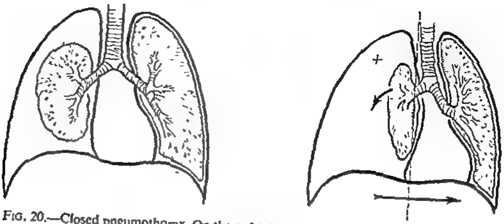


FIG. 20.—Closed pneumothorax. On the right the effects of a tension or pressure pneumothorax are shown

FIG 21.—Tension pneumothorax on the right side with displacement of the mediastinum to the left

another cause that requires little explanation since it may occur from penetrating wounds or closed crush injuries in which the lung is torn or a viscus is ruptured. Traumatic pneumothoraces are usually associated with haemorrhage and may show tension effects (Fig. 21).

The treatment of air in the pleura is unimportant when compared with that of the visceral or parietal injury. The absorption of air usually proceeds steadily but aspiration may be necessary to relieve distress.

3. SPONTANEOUS PNEUMOTHORAX

Spontaneous pneumothorax may occur as a sequel of either of two conditions: first, rupture of a tuberculous lesion into the pleura with consequent escape of air from the lung, and secondly rupture of a bulla or of a cyst without any obvious underlying pathological basis. *Tuberculosis* When tuberculosis is the cause, the onset is usually sudden with acute pain and great distress followed by fever and a rapid pulse rate. Extensive exudation or even massive infection may occur, with disastrous results. Sometimes only a small degree of fluid may exude and it may be possible to continue the spontaneous pneumothorax as an artificial one.

Pneumothorax due to a ruptured bulla may happen to persons of any age after heavy exertion or, in some instances, after a relatively slight effort, such as throwing a stone. The onset is sudden and the patient complains of severe pain with a varying amount of distress. This disappears gradually and there may be some constitutional disturbances. A tympanitic percussion note and the absence of breath sounds are usual, but a skiagram should be taken to confirm the diagnosis and to ascertain the amount of lung collapse. A pneumothorax will be clearly seen, but there may be little change in the lung tissue, and as a rule only a trace of fluid is present. This condition is likely to recur, generally with milder symptoms, but a forecast cannot be given whether, or when, such a recurrence may take place.

"Idiopathic" pneumothorax

Methods of treatment

If the opening in the pulmonary surface is of a valvular nature (allowing entry of air but forbidding its escape), a tension pneumothorax occurs with increasing intrapleural pressure, a corresponding collapse of the lung and encroachment on the mediastinum. Such a condition demands immediate relief. A hypodermic needle thrust through an interspace allows air to escape, thus balancing the pressure within and without. At best, this should be effected with a pneumothorax apparatus, but if that is not available either of the following methods may be used.

Relief of tension

Insertion of a hypodermic needle through a cork and into the pleural cavity is an elementary but effective method. The cork, cut to a suitable thickness, is held against the chest wall with adhesive tape. An elaboration of this consists of tying a nicked finger-cot over the needle hilt; thus a simple non-return valve is provided (Fig. 22). Again, a piece of fine tubing attached to the needle with its farther end under water in a bowl or a big bottle provides an effective water-seal. Whichever method is used, the aim is to obtain and maintain a normal or only slightly subatmospheric pressure in the pleural space until the opening from the lung has healed over.

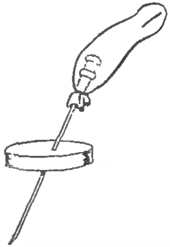


FIG. 22—Simple form of non-return valve for treatment of tension pneumothorax. A nicked finger-cot is tied over a hypodermic needle which is thrust to an appropriate depth through a cork disc.

In recurrent cases, which cause inconvenience

of 0 25–0 5 millilitre of 10 per cent solution of silver nitrate; as a precaution, a glass syringe and a needle which have been rinsed through with oil should be used. The reaction occasioned is severe and morphine may be required, but in the course of a month or six weeks satisfactory obliteration may have occurred. Should this method fail, the insufflation of 1 per cent iodine in powdered talc through a thoracoscope followed by quick withdrawal of air may produce a selective adherence. The actual fistulous opening can rarely be seen with the thoracoscope, but the apical area should be covered with powder, and all air removed.

Chemical pleurisy

In chronic cases of *spontaneous pneumothorax* associated with cystic disease, lobectomy or pneumonectomy may have to be considered

Other uncommon causes of pneumothorax are rupture of an abscess or a growth, and infection by gas-forming organisms.

4. PLEURISY

Inflammation of the pleural membrane can scarcely be considered as a distinct disease, for it is almost always due to bacterial invasion or to irritation from adjacent tissues. Such factors as exposure to cold and exhaustion cannot be substantiated as primary exciting causes, though they may well render the pleura more prone to bacterial or toxic invasion. Many of the pleurisies formerly classed as idiopathic, rheumatic and so on are now definitely accepted as having a tuberculous origin. Other affections of the pleura which do not proceed to suppuration are seen in the course of lung inflammations, and a great many of these may be of a transient and minor character, observed clinically during the pneumonitic process. The influence of chemotherapy, and particularly of penicillin, on the frequency and sterilization of effusions has not been fully ascertained.

Tuberculous origin

Clinically, two forms of pleurisy—wet and dry—are recognized The dry type is essentially a fibrinous process, whereas the wet form is characterized by a serous exudate—pleurisy with effusion.

(1) Dry pleurisy

This implies an inflammation, unaccompanied by appreciable exudation, which is usually secondary to extension from an acute inflammation or from some tuberculous focus in the lung.

(*a*) *Clinical picture*

Signs and symptoms

The signs and symptoms are usually definite. After a short period of malaise *the patient complains of pain in some part of the chest. The pain* becomes more severe, particularly on inspiration, so that he leans towards the area or endeavours to restrain the dry unproductive cough: breathing is shallow, rapid and jerky and there is obvious distress.

On examination the affected side is almost motionless and respiration is mainly abdominal; the typical friction rub heard over the affected area is diagnostic, but may be mistaken for, or indeed may be accompanied by, crepitations, the rub becomes coarser and leathery as the inflamed area becomes moist in the course of a few hours and symptoms are relieved if, and when, the pleural layers are separated by exudate.

(*b*) *Diagnosis*

Differentiation from fibrositis, pleurodynia, rib injury and neuritis (particularly that preceding herpes zoster) is simple if the rub is heard. Recovery usually occurs within a week or so, but recurrent or persistent attacks are indicative of an underlying tuberculous lesion and require careful radiological and bacteriological examination.

(*c*) *Treatment*

Counter-irritants

Treatment consists in using counter-irritants for the relief of pain and strapping of the chest to prevent painful movement. The application of adhesive strapping over the affected area precludes clinical examination and leads to

a certain amount of contraction of the chest wall, which will have to be remedied later by means of breathing exercises.

(2) Pleurisy with effusion

(a) Aetiology

Serous pleuritis is nearly always due to tuberculosis or acute pneumonitis; it may also occur as a complication in rheumatic fever, nephritis, typhoid fever (in which pneumonia is rare but bronchitis and pleurisy are fairly common), malignant growths and hepatic cirrhosis. Cold, exposure and trauma predispose to the attacks of bacteria and toxins. Effusions also occur when bacterial infections are sterilized by chemotherapy before pus develops. *Predisposing causes*

(b) Clinical picture

Symptoms The early symptoms resemble those of dry pleurisy until effusion separates the layers, when breathing becomes easier and pain disappears. Discomfort, however, may follow if the effusion forms rapidly and exerts pressure on the mediastinum. The patient lies on the affected side and, if the effusion is excessive, dyspnoea becomes noticeable and one-sided orthopnoea is adopted. A dry cough is usual and some degree of cyanosis is present. There may be high fever with increase in the pulse rate as well as in the respiration rate.

Signs The physical signs indicating the presence of fluid are well defined. The affected side is motionless and tactile fremitus is absent. In large effusions the apex beat is displaced. The percussion note over the fluid becomes more and more flat; shifting dullness can be demonstrated with moderate effusions. Skodaic resonance is present and the upper level of the dullness has a characteristic S-shaped curve. Breath sounds are greatly diminished or absent, though distinct bronchial breathing is often heard in children or when the lung is fully compressed. Vocal resonance is reduced and there is aegophony at the upper level.

Diaphragmatic pleurisy is often confused with some abdominal catastrophe. A sharp pain, almost anginal in character and occasionally associated with pain in the tip of the shoulder, is accompanied by fixation of the abdominal muscles and by vomiting. The symptomatology of interlobar pleurisy is equally obscure and often the diagnosis is arrived at only after several radiological examinations and exploratory punctures. *Unusual forms*

(c) Diagnosis

The diagnosis can be determined finally only by pleural puncture, since the clinical signs of transudate, exudate, blood and pus are similar. The appearance of clear effusions gives no clue to their origin, and bacteriological and cytological examinations are essential for diagnosis. With sterile fluids the physical and chemical characters are so variable that repeated examinations may sometimes fail in their object.

(d) Treatment

Large effusions, if untapped, may take months to resorb, and thickening of the pleura and adhesions may restrict respiratory movements and reduce the vital capacity. After extensive or repeated aspirations in the acute stages, exacerbations may occur, but effusions of moderate size resorb more rapidly after judiciously spaced aspirations than they do if left alone. Effusions

producing pressure effects demand aspiration for the relief of symptoms but, in general, aspiration should not be used too freely so long as the fluid is being absorbed.

5. HAEMOTHORAX

(1) Aetiology

(a) Pathological haemothorax

Apart from injury, blood within the pleural cavity may be the result of an inflammatory process, such as the early stages of a streptococcal inflammation, but is more usually found with new growths which have invaded the membrane. Such blood-stained effusions usually have a low haemoglobin content, indicating that there is a considerable quantity of associated effusion.

Spontaneous haemothorax

Spontaneous haemothorax is occasionally seen, and probably results from the tearing of adherent lung when a spontaneous pneumothorax develops and the lung suddenly collapses.

(b) Traumatic haemothorax

The great majority of haemothoraces, however, are traumatic and result from penetration or crush injuries (Fig. 23). Haemothorax is the commonest chest condition to be dealt with in warfare, though it may be associated with other injuries. The source of blood in most cases is from the chest-wall vessels, though it may be derived from lung, liver or mediastinal structures.

FIG. 23.—Haemothorax of moderate size resulting from a penetrating wound of the left chest.

(2) Fate of the blood

Spontaneous arrest of haemorrhage

Haemorrhage from a lung usually undergoes spontaneous arrest by pressure of the fluid. How this happens can be realized when it is known that four or five pints of fluid can be accommodated in one pleural cavity without causing mediastinal distress; the pressure of a smaller quantity than this is usually sufficient to check pulmonary bleeding. Continued bleeding from other sources, for example from an intercostal artery, may necessitate surgical intervention.

Liquid blood

The fate of the blood in the haemothorax has given rise to considerable argument and confusion. In most cases it is fluid, but sometimes it lies in clotted masses. The probable solution to the problem is based on an analysis of the haemoglobin and fibrinogen contents of the haemothorax at varying intervals after the onset. This suggests an early and rapid defibrination of blood by the violent movements of the heart and chest after injury. The

resulting liquid mass at first contains no fibrinogen, but is rapidly diluted by effusion, the fibrin content of which steadily rises until, about the tenth day, it is well above the blood level. At this point masses of fibrin are apt to be precipitated and may lead to a clotted haemo-fibrothorax. If a haemothorax occurs into a localized pleural pocket, defibrination may not take place and the blood will behave as an encysted haematoma. *Clotted haemo-fibrothorax*

(3) Treatment

The treatment of any haemothorax is primarily directed to the arrest of haemorrhage and the handling of associated injuries, if the bleeding has not stopped spontaneously. In most cases a large collection of blood and effusion, possibly with signs of pressure or tension, will be recognized and bleeding will probably have stopped. *Arrest of haemorrhage*

The policy adopted by British surgeons is that the bloody fluid should be removed as completely as possible by aspiration, beginning within 24 or 48 hours of the injury. This implies a long and patient aspiration without any admission of air into the pleura. The process should be repeated daily so that within a week of injury the skiagrams of the chest should be showing complete lung expansion, with only a limited degree of basal opacity due to pleural thickening. *Early aspiration*

Blood allowed to remain in the chest acts as an irritant. Serous exudation follows, and fibrin is deposited on the pleural surface; this not only interferes with the absorption mechanism of the membrane, but subsequent fibrosis leads to contraction of the chest and restriction of lung expansion. The deformity occasioned by an untreated haemothorax is considerable; attempts should be made to remove blood and to encourage lung expansion by the use of breathing exercises. *Untreated haemothorax*

The operation of decortication has been applied recently, and with success, to a clotted haemo-fibrothorax. This operation involves a deliberate free thoracotomy with removal of the clot and fluid followed by excision of the thick parietal and visceral fibrin layers lining the cavity. It is an operation of some severity, but it produces rapid re-expansion of the lung if performed within 6–8 weeks of injury, that is, before the fibrin deposit becomes so firmly organized that it cannot be removed without injury to the lung. *Decortication*

Infection of a haemothorax necessitates treatment along the lines of an empyema; it should be remembered that the condition, which is diffuse and unlocalized in the early stages, will probably have to be treated by preliminary and repeated aspiration until a localized pleural abscess is formed. *Infection of haemothorax*

PART II
EMPYEMA

1. DEFINITION

271.] Empyema is the term applied to any purulent collection of fluid within the pleural cavity. The different forms are classified according to their anatomical or pathological features Dependent on size and position, empyema is referred to as total, partial, encysted, apical, mediastinal, diaphragmatic or interlobar. Pathologically a broad division into acute or chronic forms can be used, and it is also possible to base a classification on the causative organism since the behaviour, for example, of streptococcal, staphylococcal and pneumococcal infections differs.

2. AETIOLOGY

Infection of the pleural cavity is invariably a secondary process and most commonly results from rupture or extension of some infective process in the lung. Pneumonia is the commonest cause, though extension from any adjacent organ, for example, subphrenic tissues, oesophagus, deep glands in the neck, rib and so on, is not rare. The disinclination of the pleura to localize an infection implies that most infections are potentially diffuse or total—diffuse suppurative pleurisy. *Localization* Localization may occur at a later stage and may produce the equivalent of a circumscribed abscess—localized pleural abscess. This distinction is important from the viewpoint of therapy, and the term *empyema is usually held to refer to the latter form.*

3. BACTERIOLOGICAL TYPES

Pneumococcal pleuritis Pneumococcal pleuritis is the commonest form of infection, and is characterized by the formation of thick pus containing heavy fibrin masses. The infection tends to become localized early with thick firm walls and, since it usually follows a lobar pneumonia after an interval, it is designated a metapneumonic empyema.

Streptococcal infections on the other hand give rise to quantities of a thin turbid fluid which produces pressure effects, but in which, though it is teeming with organisms, pus formation is slow. These infections consequently are late in localizing, and since they develop before the lung inflammation has subsided or while it is actually in progress, the term synpneumonic is used to distinguish them from the metapneumonic forms. Anaerobic streptococci are frequently encountered, and though they produce little, if any, gas, the effusion may be highly offensive. *Streptococcal infections*

Staphylococcal empyema forms thick pus and is usually secondary to a severe pulmonary infection. It occurs in children and is often associated with tension pneumothorax and consequently produces total empyema. *Staphylococcal empyema*

Numerous other organisms may be found, such as *Bacillus coli*, Friedländer's bacillus (*Klebsiella pneumoniae*), *Bacillus pyocyaneus* and anaerobic organisms. Contrary to what was originally thought, anaerobic organisms can be contained in the pleura without undue toxicity, though a certain amount of gas formation may occur. If, however, a pyogenic organism is also present the ill effects of the anaerobes are dramatically exaggerated. *Anaerobic organisms*

The empyema that occurs after rupture of a lung abscess is frequently of a mixed composition and, before the introduction of chemotherapy, was an extremely dangerous type. Empyema associated with bronchiectasis or new growth is often pneumococcal and is an example of infection in which it is important to recognize the primary cause. Tuberculous empyema will be considered separately. *Lung abscess*

4. GENERAL FEATURES

Infection of the pleura is accompanied by a serous exudate which contains fibrinogen in varying concentrations. Fibrin is deposited on the pleural surface, producing a firm thick wall to the empyema cavity, and if it becomes organized into dense scar tissue it will inevitably impede re-expansion of the lung, which is the essential feature in obliterating the space. As has been said, pneumococcal infections are particularly prone to fibrin deposit in the early stages, in contradistinction to streptococcal effusions which remain more fluid. *Pleural response*

Inspissation of pus may occur in an untreated case and calcification is occasionally seen, though its presence should give rise to the suspicion of tuberculous infection (Fig 24). *Inspissation of pus*

Fig 24.—Chronic empyema with "egg-shell" calcification of the walls There is small amount of fluid in the space.

Scarring and deformity

The thick scar tissue not only affects lung expansion but leads to contraction of ribs with secondary skeletal changes such as scoliosis. The deformity which is produced may be extreme.

FIG 25 —Total empyema (pyothorax). There is a complete collapse of the right lung with slight displacement of the mediastinum. The condition resulted from injudicious aspiration of a subphrenic abscess across the non-adherent pleural cavity.

Rupture

An empyema may rupture into the lung and be coughed up—an accident which is recognized by the sudden expectoration of quantities of pus. The dangers of flooding the bronchi with pus are considerable; pneumonitis, atelectasis, abscess and bronchiectasis are all possible results. Cure of the empyema in this way is rare. External rupture occasionally occurs and the abscess tracks along the intercostal tissues to reach the surface in the course of one of the perforating intercostal vessels, with the formation of a pointing abscess under the skin—empyema necessitatis. Prolonged toxaemia, the result of enclosed pus, is common, with the development of clubbed fingers and constitutional disability. The effects of fibrosis on the chest wall and underlying lung have already been mentioned.

FIG. 26 —Encysted empyema with smaller collection of pus in the anterior part of the great fissure.

Pyo-pneumothorax

Any fluid exudation developing within the pleural sac follows the influence of gravity so long as adhesions are not present. Most collections consequently tend to be posterior and basal, but there is also the effect of pleural capillarity which holds up the fluid at the margins, thus accounting for the radiographic and clinical findings. If adhesions are not present, the fluid shifts with

change of position. The introduction of air leads to the formation of a fluid level, and, if present in any quantity, allows the apex of the lung to collapse as well as the base, thus producing total empyema (Fig. 25). This condition is to be feared and, if possible, avoided, for the apex of the lung is always slower to re-expand than is the base.

Encysted collections in the interlobar fissures or against the diaphragm or mediastinum give rise to considerable difficulties in diagnosis and treatment (Fig. 26).

The effect of pleural infection must be regarded under two headings. First, there is the formation of an effusion which separates the pleural layers and produces a space or cavity; the underlying lung is collapsed and in tension cases the pressure effects are referred to the mediastinum, which is displaced. Secondly, there are the effects of toxic absorption from the enclosed fluid.

5. CLINICAL FEATURES

Pleural infection is apt to be overshadowed, from the clinical point of view, by the primary lung condition unless, as in the case of the now rare classical lobar pneumonia, it follows at an interval. The onset of pleural infection is characterized by pain accompanied by loss of movement over the affected area, with some increase in pulse rate. The signs of toxaemia develop, with pyrexia and increase in the pulse and respiration rates. These latter are disproportionate only if there is much collapse of lung or displacement of mediastinum. Any initial cough and pain subside as the fluid separates the pleural layers. *Onset*

Leucocytosis is common though the figure may be affected by the previous use of chemotherapy, and with an empyema of any duration secondary anaemia is invariable.

6. DIAGNOSIS

Any untoward occurrence in the presence of pulmonary inflammation should give rise to the suspicion of pleural infection, particularly if the clinical signs suggest an early pleurisy with pain at one base and with increasing dullness on percussion. The signs of pleural effusion may develop slowly over a few days but dullness to percussion, absence of tactile fremitus and muffling or abolition of previously audible breath sounds can usually be detected if careful daily examination is undertaken. Actual confirmation of the diagnosis can be established only by aspiration; the fear of puncturing infected lung, and thus producing a possible empyema, causes delay in this essential procedure in many instances. It must be admitted that in many cases an empyema is not recognized until after pus in considerable quantity has formed and pressure effects are evident; early diagnosis is the exception rather than the rule. Also, it must be allowed that radiography cannot differentiate between clear fluid and pus and, with the shadowing due to lung inflammation, small quantities of fluid are not easy to detect. Moreover, with an ill patient radiography is not always a simple procedure. Careful aspiration is the key to diagnosis. *Signs of early pleurisy* *Diagnostic aspiration*

7. TREATMENT

(1) General principles

The aims of treatment are to relieve the patient of toxic and pressure effects and finally to close the empyema space completely, so that [illegible] visceral layers of the pleura are again in ful[illegible]

Aspiration and drainage are the essential procedures on which treatment is based but the introduction of chemotherapy, notably of penicillin, has recently modified treatment to some extent since partial or complete sterilization of the pleural contents can be achieved. It must be emphasized, however, that chemotherapy in sterilizing an empyema does not obliterate the cavity, which remains a surgical problem.

The methods employed to establish effective continuity from the time that the original diagnostic aspiration is made until the final closure of the cavity vary according to the stage and form of the pleural infection. For this reason the differentiation into acute and diffuse suppuration and chronic and localized abscess is valuable.

Dangers of early open drainage

In the diffuse stage the admission of air during aspiration by open drainage allows the lung to retract and leaves the whole cavity a potentially infected space. This by itself is disastrous, since a total empyema with a fully collapsed lung may result and will take much longer to heal than will a localized pocket; there is, however, the added factor of a concomitant infection in the lung which has already impaired the respiratory function. The high mortality rate among patients with influenzal empyema in the pandemic of 1918 illustrated the extreme danger of an early open drainage.

(2) Open and closed drainage

Open drainage

The terms open drainage and closed drainage as used in chest surgery require definition (Fig. 27). Open drainage implies free evacuation of the pleural contents through a tube placed in the chest wall. Since the external end of the tube is left open, air can enter the abscess cavity at the same time as pus is draining from it In closed drainage the tissues of the chest wall are brought together to make an air-tight junction round the drainage tube which is connected to a non-return valve (a nicked glove-finger) or to a water-seal system. In this way air is prevented from entering the pleural cavity. Closed drainage is, therefore, equivalent to continuous aspiration and should be used when the pleural surfaces are free and the infection is not localized.

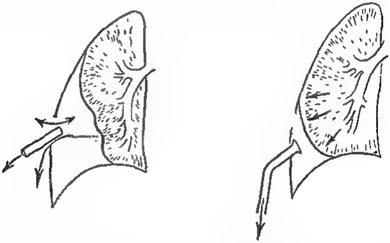


FIG. 27 —Open and closed pleural drainage

Closed drainage

The best illustration and indication for the use of the closed drainage method is during post-operative drainage of the chest after thoracotomy (should it be required). There is no theoretical objection to the use of closed

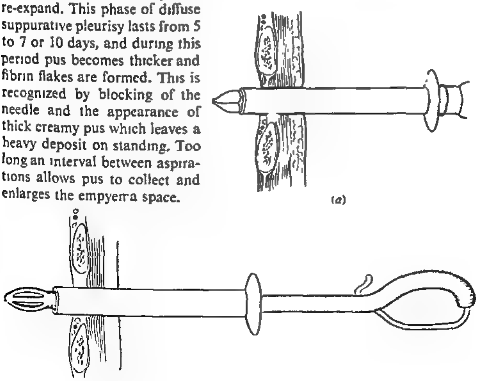
drainage in the later stages of an empyema, but there are many practical disadvantages. These have led to its exclusion from empyema treatment except in a few special instances. The objections include the difficulty of maintaining an air-tight junction between the skin and chest wall for more than a few days, the liability of a block occurring in an elaborate system of tubes and connexions—the efficiency of which is determined by their narrowest part—and the immobilization and discomfort of the patient. *Difficulties*

Open drainage can always be used when a pleural abscess has become localized and when there is no likelihood of the lung collapsing away from its adherent edges and enlarging the empyema cavity. *Pleural abscess*

Treatment can best be discussed in relation to the various stages of the pleural inflammation. The initial stages characterized by serous infected effusion are often overlooked, but diagnostic aspiration should be undertaken as soon as fluid is recognized. This allows for bacteriological examination and at the same time a quantity of fluid is kept for comparison with subsequent specimens. *Diagnostic aspiration*

Formal aspiration should be undertaken on the next day when the organism has been determined. Aspiration must be as complete and thorough as possible and air should not be admitted. At the completion, penicillin in solution is injected if the organisms have been shown to be sensitive to this form of chemotherapy. *Complete aspiration*

Aspiration and penicillin instillations are repeated as often as fluid or pus collects, sometimes every day, so that inflammatory products are removed and the lung is encouraged to re-expand. This phase of diffuse suppurative pleurisy lasts from 5 to 7 or 10 days, and during this period pus becomes thicker and fibrin flakes are formed. This is recognized by blocking of the needle and the appearance of thick creamy pus which leaves a heavy deposit on standing. Too long an interval between aspirations allows pus to collect and enlarges the empyema space. *Thickening of pus*



(a)

(b)

Fig 28.—Intercostal drainage (a) Trocar and cannula introduced through an intercostal space (b) Self-retaining Malecot catheter on introducer passed through the cannula

Extremely rapid formation of pus will lead to pressure effects with collapse of lung and displacement of the mediastinum; this may not be relieved by intermittent aspiration and requires the introduction of an intercostal tube which is connected to a closed drainage system (Fig. 28). This temporary expedient of continuous aspiration should be replaced by more efficient drainage methods within a week or so after the infection has localized.

Intercostal closed drainage

Localized pleural abscess

When thick pus and fibrin are withdrawn it can be assumed that a localized pleural abscess has formed, an event that occurs usually within 9–15 days from the onset. The thickened pleural wall can be appreciated by means of the aspirating needle, and the blocking of the needle by thick pus and fibrin masses gives evidence of the character of the empyema contents. Even though the pus has been sterilized by chemotherapy the cavity must be completely emptied. This is carried out by rib resection, a procedure that serves several purposes: it affords an opening through which the contents are removed and through which the cavity and its walls can be inspected; it also provides enough room for the insertion of a wide-bore drainage tube. The width of the intercostal spaces is too narrow to accommodate a wide tube without discomfort.

Rib resection

The operation should be undertaken deliberately and carefully, and if drainage is established the tube must lie in the most dependent part of the cavity and be left open. If the cavity walls are unduly thin and the edges not firmly adherent, the muscles and skin are approximated round the tube which is connected to a closed drainage system. This is maintained for some days until localization is assured; the tube can then be cut short and left open.

Evacuation and primary closure

There are exceptions to routine rib resection and open drainage. These include primary closure of the wound if the contents have remained sterile and if the empyema has steadily reduced in size with previous aspiration. The advantage of closure is that it precludes secondary infection which might enter through an open tube, but further fluid or pus may collect and require additional aspiration. There is also the risk that there may be an exacerbation which will later require open drainage.

There is considerable difference between the ideal treatment of empyema and the actual practice. Most cases are not seen by the surgeon until thick pus has formed, with the result that aspiration is not an important feature and treatment can start immediately with rib resection and open drainage.

Breathing exercises

The final and most important aspect is the closure or healing of the cavity. This can be effected only by re-expansion of lung, which is encouraged by active inspiratory breathing exercises. The special exercises that have been devised for use in chest surgery are of the utmost value. The concentration and strenuous efforts of both patient and physiotherapist should produce complete functional recovery by the time the empyema cavity has obliterated.

Penicillin therapy

Penicillin therapy requires a special note since its admitted benefits are being nullified in many instances by improper handling. Penicillin may and can sterilize many pleural infections, but it has no effect on the actual mechanics of the empyema cavity; if penicillin is injected after aspiration, one must be certain that the aspirations are efficiently carried out and are well timed. [illegible] ated and [illegible]

problem is then one of cavity closure and is not to be solved by p[illegible] injections of penicillin.

In some cases of empyema in which there is a virulent infection, notably with anaerobic streptococci, severe cellulitis may develop in the subcutaneous tissues after aspiration or any form of closed drainage. On such an occasion the tissues of the chest wall seem unable to deal with the infecting organisms. The condition is recognized by vivid redness developing around a black needle-puncture. Within 12–24 hours there is tenderness and the area is obviously acutely inflamed. This infection may spread rapidly in the subcutaneous planes and give rise to a condition that can be best described as spreading gangrene of the chest wall. The devastating effect of this infection leads to death in a number of cases, but since the introduction of chemotherapy its occurrence is rare. *Cellulitis* *Spreading gangrene*

Free incision of tissues with drainage may suffice in the early stages, but does not necessarily prevent the characteristic spread. This can be arrested by a circumferential incision with the diathermy needle through the full depth of healthy skin and subcutaneous tissue half an inch beyond the affected area. The procedure is a desperate one in the case of a gravely ill patient, but it has been a life-saving measure. Recent records show that this form of spreading gangrene responds to large doses of penicillin. (*See* Post-operative Gangrene, p. 108.)

(3) Aspiration

Treatment begins with diagnostic aspiration when, in the early stages, turbid fluid or thin pus is encountered. As soon as the bacteriology is determined, full aspiration is carried out with the aim of removing all possible fluid and of injecting penicillin, if suitable, 100,000–150,000 units being given. Air must not be admitted and the procedure may take 15–20 minutes According to physical signs and skiagrams, aspiration is repeated within 24 hours. *Aspiration and penicillin therapy*

The technique of aspiration is an important factor in the treatment of pleural effusions, since improper handling may produce serious ill-effects. The immediate dangers are pleural shock and air embolism, but these dangers are minimized by the use of local anaesthesia and attention to detail.

The present attitude to aspiration (excluding tuberculous infections) is that it must be made without admission of air, because in a free pleural space the air rises to the top and allows the apex to fall. If the fluid is infected, a potentially localized condition is converted into a total empyema. Also apical expansion is slower than is expansion at the base, and an apical pocket is far more difficult to obliterate than is a basal one. *Air not to be admitted*

Localization of the fluid is made by physical examination and radiography; usually the fluid gravitates towards the paravertebral gutter and in this line the eighth or ninth space is a suitable site. The apparatus consists of a local anaesthetic (½–1 per cent procaine) with syringe and needle, and a selection of needles, gauge 18, 2–4 inches long, with a two-way tap and a 20-millilitre syringe. Martin's syringe is a satisfactory example, but other special types of aspirator are permissible. The fittings of the syringe and needles must be checked before use.

The patient and the operator are made comfortable and the skin is prepared (Fig 29). The local anaesthetic is injected into the skin and subpleural area; 7–10 millilitres will suffice. The aspirating needle, attached to tap and syringe, is introduced and the pleural layer is punctured. It should be possible to *Technique*

estimate the thickness of the pleura, and then fluid or pus should be encountered. For diagnostic purposes 20–30 millilitres at least should be withdrawn so that a naked-eye specimen and one for bacteriological examination should be obtained. If infection is suspected, 120,000 units of penicillin in 5–10 millilitres of saline solution can be injected, as many of the organisms encountered are sensitive to the drug. As soon as the bacteriology has been determined, formal aspiration can take place. This follows the lines already laid down, and possibly a needle having a wider bore may be used; if the fluid volume is large the procedure may take up 20 or 30 minutes, since it must be done gradually lest the pressure becomes too "negative". Coughing and tightness in the chest are apt to occur at this stage and are relieved by a deliberate pause in the procedure.

Bacteriological examination

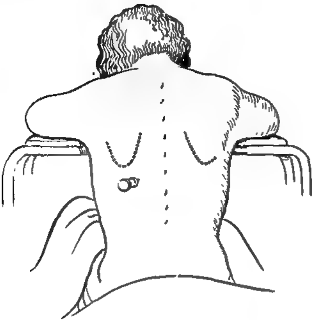


FIG 29.—Position for aspiration of the pleural cavity.

The comfort of both parties in the aspiration is important since movement of the needle may damage the lung or the chest wall. On the needle a guard which rests against the skin helps to avoid this complication. A specimen for naked-eye appearance and bacteriological examination is taken at each aspiration, and penicillin injection is probably used. Sudden stoppage of flow during aspiration may be due to blocking of the needle by fibrin or lymph flakes. The injection of a few minims of saline solution or local anaesthetic solution along the needle serves to relieve the block; recurrence of the blockage is an indication either that a needle with a larger bore should be used on this or on the next occasion, or that the pus is almost too thick for aspiration.

(a) Gas or air replacement

Gas replacement is permissible when large tuberculous collections are removed, since sudden expansion of the lung may be deleterious to parenchymatous lesions.

Air replacement is carried out by aspiration performed as described above, with an artificial pneumothorax needle placed in the second space anteriorly and connected to an artificial pneumothorax apparatus. Air is admitted as fluid is withdrawn so that the pleural pressures are maintained at a steady level.

(b) Failure of aspiration

Within 8–12 days of the onset the pus will have become quite thick and probably will only pass through a needle of fairly wide bore. A little later aspiration will become difficult, with blocking of the needle, uneven flow of pus and

so on. The empyema is becoming localized, and at this stage the chances of obtaining effective aspiration are reduced. The initial "fluid area" should be much smaller, however, and the empyema cavity confined to the lower part of the paravertebral gutter. The decision to drain must be considered as soon as it is realized that aspiration is ineffective. Recognition of the extent or of the most dependent point of the pocket can be established by injecting 5 or 10 cubic centimetres of radio-opaque oil followed by the taking of two-plane skiagrams.

(4) Resection of rib

"Siting"

The placing of an adequate drainage opening in the pleural cavity depends upon the location of the pus. The common site is in the paravertebral gutter at the eighth or ninth rib; this is confirmed by aspiration and should be within an inch of the lowest point of the cavity. Preliminary injection of a few millilitres of radio-opaque oil, with two-plane skiagrams, is a valuable method of determining the most dependent site in difficult cases.

Position of patient

Though the operation is often carried out with the patient lying on his side, it is most satisfactory to have him in the sitting position, so that there is no risk of flooding the bronchi through an unexpected broncho-pleural fistula. The patient is seated on a high stool leaning forward with arms outspread against a table, such as an operation table at full height. The surgeon sits on a lower stool behind the patient.

Anaesthesia

Anaesthesia can be either local or local with intravenous or gas-oxygen analgesia. A vertical incision is made over the site indicated and the latissimus dorsi fibres are divided. The soft tissues are retracted and the rib is exposed. The periosteum is incised and, with a rib raspatory, it is freed from the upper and lower border of the bone for a distance of 2½–3 inches. At the posterior angle of the rib the periosteum, being rougher and more irregular than elsewhere, has to be carefully detached. The deep surface of the rib is then freed, the operator remembering that the intercostal vessels lie under the sharp lower border. The denuded length of bone should be completely isolated from its periosteum before being cut cleanly with rib shears. Jagged spicules of bone are dangerous to the surgeon's finger.

Subperiosteal resection of rib

Evacuation of contents

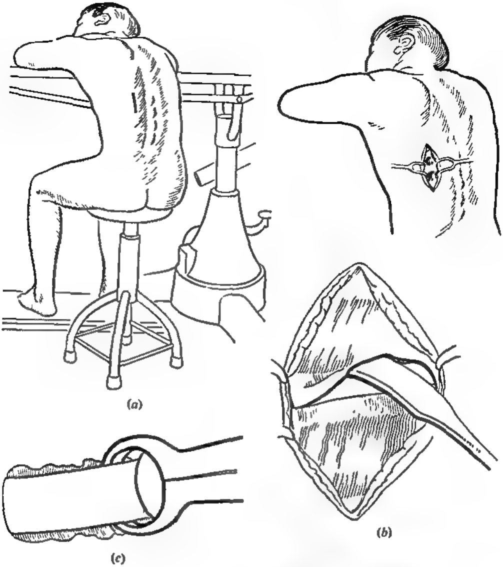
The exposed deep periosteum is excised, care being taken to avoid the intercostal vessel sand nerves when the cavity is opened. This excised periosteopleural layer is kept for histological examination. The use of a sucker is important in removing pus and lymph masses, and once the contents have been evacuated a malleable lamp is used to inspect the interior of the cavity and to see that no residual pocket or retained dead tissue is left behind. The movement of the underlying lung gives some idea of the rigidity of the cavity and of the rate at which re-expansion will occur.

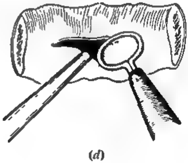
Drainage tube

A tube of wide bore is selected and carefully placed through the thickness of the chest wall, but not so far that expanding lung will impinge on it and produce ulceration. This tube is initially stitched in, but within a day or so strapping and safety-pin fixation is substituted. By this time there should be very little discharge, and the external dressing that is used consists only of 2 or 3 thicknesses of gauze held in place with a light corset of adhesive strapping (Fig. 30).

Apparatus for closed drainage

In a closed drainage water-seal system the drainage tube from the chest is led under water. An empyema bottle fitted with glass tubing is a standard





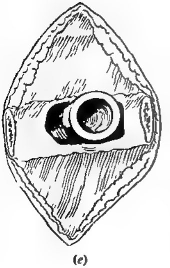
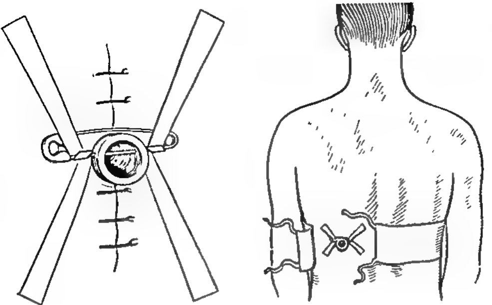


FIG 30—Rib resection and wide-tube drainage. (a) Position of the patient and skin incision. (b) Incision and reflexion of rib periosteum (c) Division of denuded rib (subperiosteal excision) (d) Opening the empyema cavity through the rib bed using a diathermy loop and sucker (e) Drainage tube inserted (the tube could be of larger size)



(f) (g)

Fig 30 (*cont*).—(*f*) Suture of wound and fixation of open-drainage tube (*g*) Adhesive corset for holding light dressing in place.

apparatus (Fig. 31), and the subatmospheric pressure causes the water in the bottle to rise up the terminal length of tubing where it rises and falls with each respiration. The weak mechanical points of the system lie in the connexion between lengths of rubber tubing; these tend to become blocked and the swing in the bottle tube will stop Looping or kinking of the tubing may also interfere with drainage which can be started again by watching the mechanics of the system and judicious milking of the tubing if it is blocked. Attention by the nursing staff to the position of the tubing and pillows is important if the patient is to be comfortable.

(5) Drainage

Drainage, as has been indicated, is satisfactory only after rib resection, which gives room for insertion of a wide drainage tube which will not press on the periosteum or the intercostal nerve. An intercostal tube rarely, if ever, affords adequate drainage; blocking by fibrin or "lymph" masses occurs and pain is common. Pain always tends to make the patient bend towards the affected part, so that in this case the increased pressure exaggerates the symptom and hinders free movement of the chest wall. Unless there are specific indications drainage should be open.

Placing of drainage tube

The drainage tube is carefully placed so that the internal opening lies comfortably inside the cavity but without impinging on expanding lung. There should not be a side eye which could become entangled in the tissues of the chest wall, although, if a long narrow track is encountered one or more side [illegible] be considered. The external projection of [illegible] slipping by [illegible] ow lengths of adhesive tape arranged in the form of a cross.

Fixing of tube

Early mobility

Within a day or so the patient is encouraged to move out of bed, if the general condition permits, and the volume of drainage should rapidly

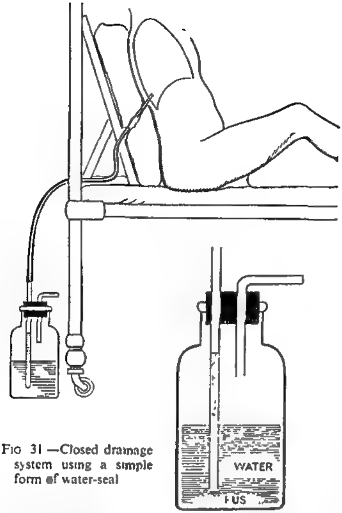


FIG 31.—Closed drainage system using a simple form of water-seal

decrease to a minimal amount if the cavity has been properly emptied and pockets or loculi are not left. Breathing exercises and activities already started during the aspiration period are enforced with increasing vigour and continued throughout the whole treatment.

(6) Control of the healing empyema cavity

The drainage tube must not be removed in any *circumstances if the size* or shape of the internal space is not known. This internal healing can be gauged by ordinary radiography if the cavity is large, or by the injection of radio-opaque oil followed by taking two-plane skiagrams

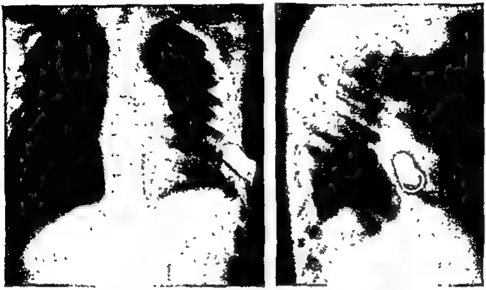
Pleurogram

(pleurograms) (Fig. 32). The pleurograms are repeated at regular intervals of, say, 10–14 days and are studied in relation to the draining tube. Alteration in the size or length of the tube is unnecessary if uniform concentric healing occurs, but "bottle-neck" tracks or irregular limbs may require longer tubes, or their manipulation, to maintain adequate drainage.

Tube not to be changed too often

Too frequent removal of the tube for cleansing is unnecessary. Tube changes should be made only in response to alterations in the pleurograms. Final removal of the tube should

FIG 32.—Pleurogram, lateral view. Note the tendency to "bottle-neck" formation. The ring marks the skin opening of the drainage tube.



(a) (b)

FIG. 33.—Pleurogram showing empyema approaching final healing (a) Antero-posterior view, and (b) lateral view. The tube can be removed at this stage.

take place only when the open granulating surface is simply a track through the chest wall (Fig. 33)

Occasional bacteriological control of the cavity is advisable since it is *admitted that, with open drainage, there is infection by secondary contami-* nating organisms which delays healing. *Bacteriological examination*

In a straightforward case, if the rib resection is undertaken within 2–3 weeks *of the onset of infection, the final healing occurs within another 4–6 weeks.* *Time factor*

Late diagnosis and imperfect control of drainage *contribute to delay the final* healing and the common factors are considered under Chronic Empyema on p 81. In all instances the patient with a "drained" empyema should be comfortable and ambulant, and increasing activity in physiotherapy can be persevered with in a very few days.

FIG 34.—Encysted pleural effusion (purulent) in the left upper zone with a small diffuse collection at the base.

The drainage of encysted forms, such as the interlobar empyema, may occasion difficulty Careful localization by radiography (Fig. 34) should be followed by aspiration in the operation theatre *Encysted forms*

where, if pus is recognized, drainage can be established by follo course of the needle. If pus is not found with the needle a delib resection may be performed, and, without opening the pleura, a opaque marker (soft wire in rubber tubing) placed in the rib bed. Aft localization, aspiration can again be attempted within 10 days abscess being treated along the lines of a lung abscess.

Irrigation

Irrigation of the pleural cavity has fallen into disuse. It had certain cal and antiseptic values, but the dangers of flooding the lung thi

(a) (b)

FIG 35.—Residual pleural pocket resulting from slow expansion at the apex Th "bottle-neck" between the pocket and the long tube track which leads from the drainage opening A broncho-pleural fistula is also present. (a) Antero-posteri and (b) lateral view.

Broncho-pleural fistula

unsuspected broncho-pleural fistula were considerable (Fig. 35). A sus fistula can be demonstrated by injecting methylene blue, which will the sputum; alternatively, oil of peppermint, which is quickly tasted be injected.

(7) Breathing exercises

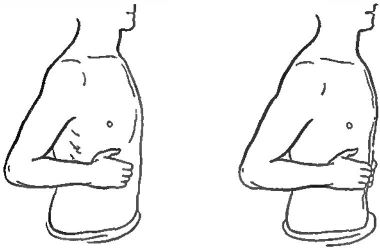
Inspiratory efforts

Purposeful, vigorous exercises—one of the most valuable developme chest work in recent years—aim at active and localized inspiratory effo that with practice and education the patient can concentrate a cont inspiratory effort over the part of lung to be expanded. Provided th skeletal changes have occurred it is possible, with the use of exercises ca on conscientiously and energetically for a period of weeks, or even mo to restore a contracted and fibrotic chest to normal.

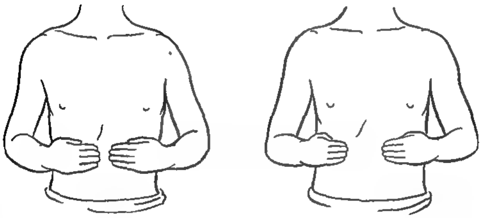
Localization

The exercises are begun as early as possible in the case of empyema—al as soon as the patient comes for treatment. The physiotherapist uses pre of her hand on the chest wall to direct the patient's efforts. The exer employed usually aim at basal expansion, using rib and diaphragn

movements in all possible directions (Fig. 36). Apical expansion, though less important, is also to be encouraged. It must be emphasized that the whole effort is inspiratory and that the expiratory exercises often prescribed are of little value. Webbing belts to enable the patient to make a point of pressure



(a)



(b)

FIG. 36—Breathing exercises with localized inspiratory effort. (a) Lower costal movement controlled by light pressure of the hands over the required area (b) Diaphragmatic movement concentrated by pressure of the finger tips just inside the costal margin.

to work against are useful, but the whole performance must be concentrated and persistent, at most chest clinics less than 10–15 minutes' exercise in each of the patient's waking hours will be regarded as unsatisfactory. *Perseverance*

At chest hospitals and units emphasis is placed upon class exercises, in addition to individual tuition, these develop enthusiasm and encourage an active competitive spirit. The classes are co-ordinated with other rehabilitation measures so that ■ patient who has an empyema, for example, spends his waking hours in a normal busy environment which hastens his recovery. He is rarely bedridden.

8. PLEURAL INJURIES: SECONDARY INFECTION

(1) Chylothorax

The presence of chyle in the pleural cavity is important since the fluid when it is withdrawn resembles pus on sight; it consists, however, of fat globules. The fluid which has entered as a result of injury to, or of pathological effusion from, the thoracic or lymphatic ducts has a specific gravity of over 1 012 and, if shaken with ether and potassium hydroxide, the fat dissolves, leaving a clear liquid. A fat-staining dye such as Sudan III will colour the fluid. Occasional aspirations relieve the condition if an underlying cause such as malignant disease is not present.

Pseudochylous effusions

Pseudochylous effusions are sometimes found; their appearance is derived from refractile granules produced by degeneration of cells within the fluid. This lecithin-globulin complex does not dissolve in fat solvents, nor does it stain with Sudan III.

(2) Cholothorax

Injury

Bile may enter the chest as the result of an injury which involves the liver and pleural cavity and, more rarely, it occurs after hepatic suppuration with ulceration through the diaphragm. Infected amoebic abscesses rupturing into the pleura are comparatively common and, after aspiration or drainage of the amoebic contents, a persistent biliary fistula may result.

Amoebic abscess

Bile is intensely irritating to the pleura; it provokes effusion and leads to fibrosis later. Energetic aspiration is indicated but the future course of the chest condition is determined by the liver damage.

(3) Subphrenic abscess

Effects on pleura

Infections immediately below the diaphragm are often associated with some degree of pleural effusion. This is referred to as a sympathetic effusion, but its irritative character is shown by its rapid disappearance if the subdiaphragmatic abscess is drained. Empyema is common in untreated cases and may result from direct ulceration through the diaphragm. In many cases, however, the lung becomes adherent to the diaphragm and pus is coughed up without infecting the pleural cavity.

Sudden rupture through the diaphragm produces a virulent empyema. Gas-forming organisms are usually present and a sudden total empyema is formed. Shock and toxaemia are severe and the aspirated pus is of a most offensive character.

Dangers of aspiration or transpleural drainage

Another important point in connexion with subphrenic collections of pus is the method of aspiration and drainage. If the needle traverses the pleural cavity when exploring for pus there is always a possibility of infecting the pleura; even more disastrous is an attempt to drain the subphrenic region across the free margin of the pleural cavity. This results in an open pneumothorax with probable total infection. Any attempt at drainage must be established below the pleural limits or across a firmly adherent pleura. The adherence of pleura may have been established by disease but, if not, it can be produced by preliminary packing or "tamponade" after the method of draining a lung abscess in two stages. Suture of lung to the wound edges to

prevent its collapse and to limit infection is often quoted, but this method should be condemned outright as ineffective.

9. CHRONIC EMPYEMA

(1) Aetiology

Excluding tuberculous empyema, a large proportion of chronic pleural infections result from unsatisfactory treatment of the acute stages. There is, however, another group associated with such conditions as bronchiectasis, new growth or actinomycosis, in which in spite of proper treatment the empyema will not heal until the underlying cause has been removed.

Maltreatment of acute stages

The numerous errors and imperfections in the handling of the earlier phases of pleural infections reflect badly on current medical and surgical teaching.

Common errors

Common causes are: drainage instituted too late, inadequate tubing which is often wrongly placed, failure to maintain adequate drainage and undue persistence with chemotherapy. Thus it is common to find that the empyema has been opened too high and too far forward, leaving an undrained pool of pus and that, compared with the available opening, too small a tube has been inserted.

The habit of removing the tube frequently for cleansing induces cicatricial contracture of the opening with consequent pain on its reinsertion. A narrower tube is used and then one still narrower until, in the course of time, a large empyema cavity is left which the tiny tube cannot drain. The question of foreign bodies—sequestrum of rib, or a mislaid tube or swab—has to be considered, but an efficient film or a pleurogram will confirm or disprove their presence, and these causes are fortunately not so common as might be expected.

FIG 37.—Chronic empyema of many years' standing showing a gross postural deformity.

(2) Clinical features

The clinical picture of chronic empyema is essentially one of prolonged toxaemia, often associated with a severe degree of secondary anaemia. In some, which have not been drained and in which an inspissated empyema of long standing is present, the condition may not be recognized until the chest is carefully examined. Usually, however, drainage will have been instituted and a continuous discharging sinus, or one that intermittingly closes, will be seen.

Deformity

The local signs are those of restricted movement and a rigid non-expanding lung. In severe cases the deformity of the chest is accompanied by marked

scoliosis. Radiographically there is a uniform area of opacity which obscures lung shadows and there may be fibrotic contraction of the mediastinum towards the side, as well as falling in of the ribs (Fig. 37).

(3) Treatment

Investigation The first steps in the treatment of any chronic empyema are to ascertain its extent and size. This can be done by means of a pleurogram when a drainage opening is present, and even if the empyema is closed it should be possible to inject radio-opaque oil through the grossly thickened pleura.

Re-drainage It is almost always advisable to perform a minor thoracotomy by resecting a short length of rib over the most dependent part of the cavity, once this has been defined by the pleurograms. A section of thickened pleura should be removed at the same time for histological examination and, if the opening is large enough, the interior of the cavity can be inspected or palpated to exclude the presence of alien tissue or an unexpected loculus. A wide, open drainage tube is then inserted and maintained in place.

Physiotherapy General improvement soon follows and with strenuously applied breathing exercises the chest wall will begin to move again. The majority of empyemas show slow but steady progress towards closure, even though 3–4 months may elapse from the time of drainage, and so long as some progress is being made there is no reason for further interference. The use of chemotherapy, both systemically and locally, will depend on the type of organisms encountered; too great a dependence should not be placed on these agents, since the problem is primarily the closure of a cavity.

The patient can be up and about within a day or so of operation, and in many cases can return to work with an open drainage tube and a light dressing, so long as a rigid check is made at stated intervals—say, every 2 or 3 weeks.

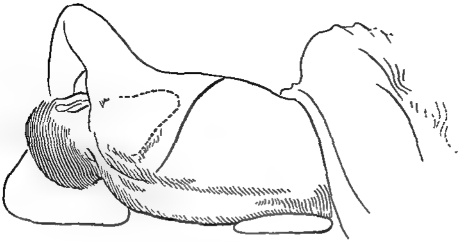
In cases in which the condition has become static for several weeks the question of some additional procedure may have to be considered. Operations to close a resistant cavity come under two headings.

(a) Excision of the restricting visceral pleura—decortication.

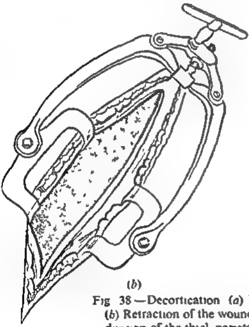
(b) Mobilization, or excision of the thickened chest wall, so that the outer surface of the cavity falls in against the lung.

(a) *Decortication*

This operation, which has returned to partial favour after its employment in haemo-fibrothorax, consists in a free opening into the cavity with incision through the thick pleura covering the lung. The plane of cleavage between the pleura and the lung is then extended over the cavity, so that the lung surface is, theoretically, left as a soft expansile area. In practice, the operation is of use only in subacute cases in which an unduly large amount of fibrin has been deposited In chronic cases the fibrous coating has become so closely adherent to the lung that it cannot be removed without tearing the surface of the lung and producing a bubbling, bloody surface. If decortication of the lung is possible, the excision of pleura should be continued round the edges and over the surface of the chest wall, so that the operation really constitutes an excision of the pleural abscess cavity *in toto* (Fig. 38). The procedure entails a considerable degree of shock, and should be reserved for cases in which the



(a)



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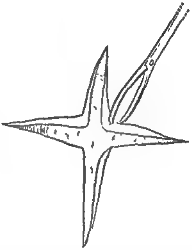

(c)

Fig 38—Decortication (a) Position of the patient and incision. (b) Retraction of the wound after excision of a length of rib and division of the thick parietal pleura (c) Cruciate incision through the visceral pleura exposing lung surface and showing how flaps can be started.

early deposit of fibrin is unduly large and in which there are loculi or pockets which simple drainage is not likely to empty.

(b) *Muscle grafts*

A small residual cavity can be obliterated by the insertion of pedicled muscle grafts derived from intercostal bundles, the latissimus dorsi and other muscles of the chest wall. The criteria for this type of procedure are a bacteriologically clean cavity and one of a capacity sufficiently small to be filled by the grafts. It is of value in cases in which there are persistent and rigid cavities little more than a tube track in size, but it is not a simple matter to obtain pedicled grafts of any large size.

(c) Thoracoplasty

There are two forms of rib resection that can be used in the treatment of chronic empyema; both are undesirable if any simpler method is likely to succeed.

Shock and haemorrhage

The first, which is a modification of the classical Schede thoracoplasty, consists in removal of ribs over the cavity plus excision of the parietal pleura, so that the skin-muscle flap is applied directly on to the pulmonary surface of the cavity. Because of shock and haemorrhage the operation has to be performed in stages, and it should be realized that division of the lower intercostal nerves will lead to paralysis of abdominal musculature.

The Roberts operation, which is a modification of this, includes rib resection followed by hinging of the thick parietal layers, and pressing the flap into the

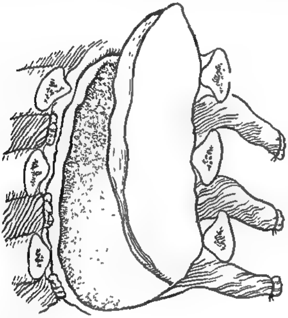

FIG 39.—Operation for persistent chronic empyema. Ribs have been removed over the cavity and the intercostal bundles divided. The thick parietal pleura is either cut away or cut with a hinge so that it can fall in on the visceral layer.

cavity. In all these cases a great deal of improvisation is required and a large bare area is often left to granulate as best it can (Fig. 39).

Paravertebral thoracoplasty, as used with tuberculous empyema, is very rarely indicated, and even then it only assists in crumpling up or in reducing long narrow tracks that have failed to heal in any other way.

It is essential that these mutilating operations should be used only as a last resource when, after months of treatment, the failure of adequate drainage and breathing exercises is unfortunately evident.

(4) Conclusion

Chronic empyema is a very serious disability which may be avoided by adequate treatment of the acute condition. An established chronic empyema will cost the patient months of disability and the surgeon and his helpers months of anxious treatment. The bacteriological flora should not be forgotten and should be regularly examined; the use of various antiseptic and chemical agents to promote fibrous tissue and healing is helpful, though their efficiency is variable. When an underlying condition, either tuberculous or malignant, is recognized by examination of the discharge or of the pleural

biopsy a permanent drainage will probably be required, and if the presence of a drainage tube is regarded as too much of a burden to the patient, the turning in of a small skin flap will remove this worry, though it will not affect the amount of discharge and the necessity for dressings. *Permanent drainage with skin flap*

PART III
TUBERCULOSIS OF THE PLEURA

1. INTRODUCTION

272.] Tuberculous infections of the pleural cavity constitute a special problem both in diagnosis and in treatment. The forms that are encountered range from simple effusion to gross infections with tubercle bacilli and with pyogenic organisms.

2. TUBERCULOUS EFFUSIONS

(1) Aetiology and diagnosis

It may be repeated here that apparently simple pleural effusions are often tuberculous in origin and are due to irritation of the pleural membrane by a subpleural focus

The term "primary effusion" is also often applied to cases in which an effusion is seen in young adults who do not present any other evidence of pulmonary tuberculosis. Pathologically, there may be evidence of tubercles elsewhere, suggesting that a blood-borne infection of miliary character has occurred and in this type it is not surprising that effusions in other serous cavities may follow or be concomitant. Pleural effusions frequently form part of polyserositis or polyorrhomenitis.

The complete resolution of many of these effusions without any evidence of tuberculous disease in the lungs makes their diagnosis difficult, but it is generally accepted that, unless some other cause for the effusion is recognized, a tuberculous origin should be admitted and the condition treated as such.

The significance of a primary tuberculous effusion is that it carries the risk that in 20 per cent of the patients pulmonary tuberculosis will develop within 5 years.

(2) *Clinical features*

The onset of an effusion varies from the occurrence of minimal symptoms to an acute febrile and constitutional disturbance. Vague and almost unnoticed ill health may be the only feature and the presence of fluid may be recognized only by clinical and radiological investigation (Fig. 40). At the other extreme, high fever with pain in the chest is followed by a rapid outpouring of fluid which may lead to loss of movement of the chest, collapse of lung, and even displacement of the mediastinum with accompanying distress.

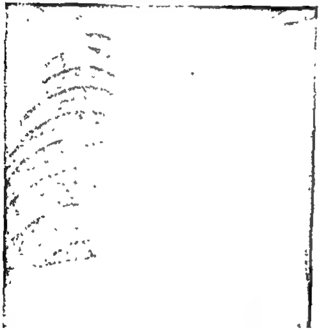

FIG 40.—Large left-sided pleural effusion which was found to be of tuberculous origin

Character of fluid.—Confirmation of the presence of fluid is ensured by aspiration, during which clear straw-coloured fluid is withdrawn. This fluid may clot partly or almost wholly; it has a variable cell content, with lymphocytes predominating. When bacteriologically cultured the fluid is sterile. Special cultures and guinea-pig inoculation may reveal tubercle bacilli.

(3) Prognosis

A small, symptomless effusion will probably resolve without incident in the course of a few weeks, though the risk of later pulmonary involvement suggests that a prolonged period of convalescence and observation will be necessary.

Patients who show a marked reaction may continue to have raised pulse and temperature rates for a period of weeks before the condition subsides. It may be necessary to aspirate quantities of fluid to relieve pressure effects, but there is no guarantee that the fluid will not speedily re-collect. Frequently the process of aspiration leads to a sharp reaction, and this suggests that the pleural membrane should be left untouched as long as possible.

Artificial pneumothorax The presence of an effusion is a common finding at some time or other in the course of an artificial pneumothorax but the majority of these effusions are transient in character. It is only when they are persistent or become turbid that an empyema is to be feared, particularly if the pneumothorax is contra-selective, or when adhesions are present. The tearing of adhesions gives rise to some effusion, but if lung substance is torn an empyema is the probable outcome.

(3) Complications

Pressure effects, naturally, are seen when the fluid or pus is formed rapidly, but usually the process is slow; the lung collapses gradually and the pleural fibrosis gives some rigidity to the mediastinum and delays its displacement.

Development of deformity The effect of fibrosis is to produce a firm layer of fibrous tissue on the chest wall. This leads to contraction of the intercostal musculature and approximation of ribs in the expiratory position, so that the chest wall is flattened and rigid. Secondary changes occur when ribs take on a triangular cross-section and overlap like tiles on a roof. The alterations in the chest wall lead to scoliosis and deformity. The fibrotic layer over the lung steadily undergoes cicatrization and by sheer mechanical constriction prevents movement and expansion. This feature has a most important bearing on treatment, since it is possible to obtain complete or partial expansion of the lung in the early stages of the empyema, but, once a constrictive pleurisy has developed, re-expansion is almost impossible.

Constrictive pleurisy

Encysted pus behaves as does a "cold abscess" and may undergo inspissation, but is more likely to ulcerate into the lung and lead to a pleuro-bronchial fistula, through which the empyema contents are discharged. This induces attacks of coughing, or it may lead to lung-flooding if the patient suddenly changes position. Quantities of pus are expectorated, and it is only a question of time before permanent damage is inflicted on the lung. External rupture occurs along the track of an aspirating needle, or pus burrows into the intercostal tissues and finds its way to the subcutaneous tissues along the course of nerves and vessels. It is important to keep the puncture track uppermost for some time after aspiration so that the needle track is not bathed in pus. Fluctuating swellings of variable size are encountered and these may break through the skin to produce persistent discharging sinuses. The presence of sinuses and chest-wall infections seriously affects the planning of any major surgical operation, such as thoracoplasty.

Fistulae

Sinuses

Associated secondary infection will almost certainly occur if sinuses develop.

End-results Prolonged toxaemia and amyloid disease are common complications, which can be readily recognized from the waxy pallor of the skin, enlargement of the liver, renal casts in the urine and so on.

(4) Types of tuberculous empyema

Several forms of empyema are described, though such a division is arbitrary, and the forms merge into each other.

(a) *Clear effusion*

This form, which implies an actual involvement of the pleura by tuberculous tissue, is an exaggerated variety of tuberculous effusion. There is a clear, or

slightly turbid, fluid which contains actively proliferating tubercle bacilli. There is no question of culture or guinea-pig inoculation being required for recognition of the organisms; they are there in appreciable numbers. The slight deposit is due to cell debris, and organisms and white cells may be present. Polymorphonuclear leucocytes and old blood cells are present in small numbers in the early stages of the irritation, but lymphocytes appear in the later stages, and flakes of fibrin and lymph are absent.

(*b*) *Purulent effusion*

In this form the fluid is definitely purulent and has a high cellular content. The colour is greenish and quite opaque, though the fluid does not approach the thickness of pneumococcal pus. Lymphocytes are predominant, but the presence of tubercle bacilli on direct films is inconstant. On ordinary bacteriological culture the fluid is recorded as sterile. The pleural surfaces show an appreciable deposit of film, which may attain a thickness of three-quarters of an inch on the parietal surface as time goes on.

These purulent collections, if aspirated frequently, may become contaminated with staphylococci or streptococci in small numbers and the appearance of those organisms is associated with the reduction or absence of tubercle bacilli. If this unimportant secondary infection does not extend, the pyogenic organisms will probably die off and again tubercle bacilli will be seen.

(*c*) *Mixed infection*

Associated pyogenic and tuberculous infection

The most dangerous form is one in which pyogenic and tuberculous infections are associated. This results from extensive rupture of infected lung tissue as in spontaneous pneumothoraces, or from the rupture of a tuberculous cavity in the course of an unsatisfactory pneumothorax. The combined infection produces extremely grave symptoms and may lead to early fatality. Tension phenomena are common, and the condition requires urgent treatment if the combined mechanical and toxic effects are to be overcome.

Penicillin therapy

Some mixed infections are less severe and, so far as the pyogenic aspect is concerned, can be controlled by penicillin therapy, so that with luck the condition is converted into ordinary tuberculous empyema. In most of these cases the lung is collapsed and remains in that condition without any tendency to re-expand.

(5) Treatment

(*a*) *General principles*

Treatment is too often tentative in the early stages; a simple and early condition is treated so timidly that a completely collapsed lung lies permanently against the mediastinum, incapable of re-expansion. The dead space consists virtually of the whole pleural cavity on that side, leaving a vast area of exposed and open tuberculous granulation tissue, and the possibilities of internal and external perforation remain. The governing principle in all cases must be to close the pleural space as soon as possible by obtaining expansion of lung, or, if that fails, by mobilizing the chest wall and allowing the parietal pleura to fall in on the visceral layer. The commonest cause of failure occurs when the empyema first develops. Unfortunately the evolution of an effusion, incidental to the course of an artificial pneumothorax, into a tuberculous empyema is allowed to occur without active measures being taken. Effusion

Usual errors in technique

is wrongly thought to be beneficial in maintaining pulmonary collapse whereas the lung lesion should be regarded as subsidiary to the pleural condition in these cases.

(b) *Aspiration and re-expansion of lung*

Once the empyema is recognized, the fluid should be aspirated frequently in an endeavour to relieve pressure on the lung and to encourage its re-expansion. The artificial pneumothorax should be abandoned once it is realized that the pleural involvement is definite. If this measure is undertaken promptly, and before the constricting effects of the pleurisy develop, lung expansion and obliteration of most of the pleural cavity follows. The base will probably expand readily and, if any danger is expected from opening up cavities in the collapsed upper zone, a limited thoracoplasty can be added to the treatment without much delay. When thoracoplasty is contra-indicated, some reduction of space may be achieved by an early phrenicectomy and pneumoperitoneum.

(c) *Pleural lavage*

If there is appreciable pleural thickening, aspiration can be supplemented by pleural lavage with a suitable antiseptic or bactericide. Flavine and azochloramide wash-outs are occasionally followed by some re-expansion of lung; in all cases the pleural pressures after aspiration should be left at a subatmospheric and negative level. Better results are probably obtained from

ntibiotics

the use of instilled antibiotic agents, such as streptomycin, or specific agents, such as *para*-aminosalicylic or *para*-aminobenzoic acids, but though their effect on tubercle bacilli may be satisfactory the lung expansion has still to be considered.

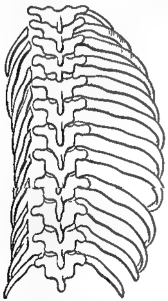

FIG 41.—Total thoracoplasty to show the extent of collapse that can be obtained by a multiple-stage operation In practice almost the whole of the upper four or five ribs would be removed.

(d) *Thoracoplasty*

When the pleural layers are rigid the only hope for final obliteration of the cavity lies in thoracoplasty. The procedure involves multiple stages—usually from 3 to 5—with massive resection of the first to the tenth or eleventh rib. Even this may fail to close the final pocket lying against the mediastinum above the diaphragm. Supplementary operations may obliterate this space, and the methods of pleural excision, muscle flaps or wide excision of all overlying tissues meet with varying success.

This total form of thoracoplasty (Fig. 41) *should never be compared* with that employed for parenchymatous disease. The operations are undertaken on patients with severe toxaemia and the ribs are firm and rigid; shock may be considerable, and sinuses or infection of chest-wall

Deformity

tissue may lead to infection of the incisions. Also, the deformity even in a successful operation is usually marked, in spite of energetic physiotherapy.

(e) *Drainage and chemotherapy*

[illegible] *Mixed infection*

and this still applies to cases that are not controlled by chemotherapy. The site for drainage should be placed as far down as possible (tenth or eleventh rib) to avoid any future thoracoplasty incision. Drainage in the axilla is sometimes advocated in order to avoid this contingency, but this is inferior to drainage in the paravertebral gutter, or at the lowest point of the pyothorax. Tube drainage is not always comfortable in the later stages, and the turning in of a small skin flap is called for to produce an epithelialized track which will remain permanently open and will not require a tube. As soon as possible a total thoracoplasty will be required. Drainage is also indicated in the presence of an internal fistula if aspiration fails to keep the space empty.

It will be noted that thoracoplasty is advocated in most cases, but this is contingent on the general condition of the patient, and the condition of the opposite lung. If the "sound" lung has withstood the strain imposed on it by complete collapse of its fellow, it will probably withstand thoracoplasty on the side of the empyema since the lung is already fully collapsed.

(f) *Skin-flap drainage*

Energetic surgery is sometimes contra-indicated by the patient's general condition. The problem then is to decide whether to do nothing and risk perforation and toxaemia, or to persist with aspiration and lavage. With multiple fistulae through the skin, the discomfort of a persistent and widespread discharge can be overcome by establishing a skin-flap drainage so that one dressing will suffice, and, if that drainage is dependent, the volume of discharge will be rapidly reduced. *Multiple fistulae*

PART IV
ACTINOMYCOSIS; NEW GROWTHS

1. ACTINOMYCOSIS

273.] Actinomycosis may invade the pleura from the lung and produce a local adherent condition in the chest wall with multiple discharging abscesses, or a pleural infection of subacute or chronic degree. The diagnosis is made by recognition, or culture, of the specific fungi in the pus, which is always offensive. The prognosis of pleural actinomycosis was at one time thought to be most grave, and indeed fatal, but even before the introduction of penicillin a number of cases treated by the methods applied to an ordinary empyema, *Diagnosis*

responded well to drainage. Since the introduction of penicillin a further measure of control has been provided, though it seems probable that prolonged and extensive use of the drug will be required to defeat the more serious degrees of infection. Less severe forms respond well to drainage, once the abscess has become localized and small. Iodine and iodides in massive doses have some value in reducing the infection and the cellular proliferation.

2. NEW GROWTHS

Primary neoplasms arising in the pleural membrane are uncommon, but invasion by direct spread from a pulmonary growth is often seen. Multiple secondary deposits from extrathoracic organs also occur and these generally give rise to effusions.

(1) Primary neoplasms

Tumours of pure pleural origin—even endotheliomas about which there is some divergence of opinion—are mostly of academic interest. Lipoma, fibroma and haemangioma have been recorded, though there is a possibility that they have arisen from subpleural structures and thus have developed an intimate connexion with the pleura. Simple pleural cysts are more frequently found, but again there is difficulty in distinguishing these from pleural pockets produced by adhesions or previous inflammation.

Endothelioma is regarded as a tumour from the serous surfaces and is characterized by flat plaque-like masses of growth which are accompanied by effusions and haemorrhage. The histological picture is not characteristic, though the typical oval endothelial cell should be present. It is probable that many examples of so-called endotheliomas are secondary tumours or are lung tumours directly infiltrating the pleura.

Direct spread.—The presence of a clear or blood-stained effusion in association with a pulmonary neoplasm usually indicates invasion of the visceral pleura. It is sometimes suggested that obstruction to pleural lymphatics at the hilum produces an effusion, but surgical experience with such cases shows that the pleura has been affected; even after a successful pneumonectomy, early recurrence suggests that pleural involvement had been present at the time of operation. In other words, the presence of an effusion associated with a pulmonary growth probably excludes radical surgery.

Diagnosis

Cytology of effusion

The diagnosis of an effusion suspected to be of malignant origin may be confirmed by aspirating a quantity of effusion and centrifuging it. The deposit is fixed and sectioned and is examined for cells which are diagnostic of, or which suggest, malignancy.

The presence of blood is suggestive of a malignant effusion, but it must be ascertained that the aspiration was a "clean" one and that vessels in the chest wall were not punctured.

Sarcoma, chondroma and similar tumours of the ribs and chest wall tend to [illegible]

after secondary mammary cancer are usually due to direct invasion from chest wall or the internal mammary chain of lymph glands.

(2) Secondary metastasis

The pleural cavity has an almost selective attraction for certain types of carcinoma. Gastric growths with diffuse seedling secondary growths may produce pleural deposits which are sometimes blood-stained. Ovarian carcinoma has a similar predilection for the serous membranes, and a pleural effusion, usually on the right side, accompanied by a mass in the pelvis gives rise to the suspicion that this condition is present. Meigs's syndrome, consisting of the association of a clear pleural effusion with a soft ovarian fibroma, is an interesting variety which should be mentioned in this connexion.

Diagnosis

Effusion is characteristic of multiple secondary deposits, and malignant cells may be recovered in the fluid. Aspiration with gas-replacement gives an opportunity for thoracoscopy, during which the judicious use of pleural biopsy is of value in diagnosis. Multiple deposits are usually widespread over the pleural membrane and resemble tubercles, with which there is often confusion on inspection Plaque-like masses are less commonly seen, though they are sometimes associated with lymphadenomatous deposits.

The presence of an effusion in an individual of middle age is invariably a matter of difficulty in diagnosis The absence of any abnormality in the lung places the probability between tuberculosis and secondary deposits, but the distinction may be very difficult to make in the absence of positive bronchoscopic or bacteriological evidence.

[References to other titles are given under Pleura—Diseases of in the Index Volume. The subjects of Empyema *and* Pleurisy are also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 4, p 520, *and* (1938), Vol 9, p. 699.]

POLIOMYELITIS

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1. DEFINITION

Causal organism

274.] Poliomyelitis is an acute infection of the central nervous sys filter-passing virus of which there appear to be several strains. mately 50 per cent of those contracting the disease paralysis, eithe or permanent, develops, and in most cases this paralysis is flacc

2. AETIOLOGY

Although it is generally accepted that the disease is caused by a fi virus, certain workers, amongst them Rosenow (1944), consid causal organism is a strain of streptococcus. The disease is limi but it can be transmitted to certain of the apes, and Lansing's str be transmitted to mice. Little is known of the epidemiology, anc of entry has not yet been definitely determined Investigations times incriminated the upper respiratory tract and at other times intestinal tract. Transmission of the disease has been obtained exp by injection of material from the nasopharynx, the mesenteric the faeces of infected persons

Poliomyelitis occurs endemically throughout the world at all se epidemics occur typically during the late summer and the earl major epidemics have occurred in Scandinavia, the United States o Australia and, in 1947, in Great Britain. It was hoped that the inv into epidemics in the islands of Malta, Mauritius and St. Hel clarify the epidemiology of the disease, but results have been conflic

Children under 5 years of age are the most commonly affected, but adults are not immune to the disease and the age incidence has shown a definite rise in the most recent epidemics. Permanent immunity is probably produced by an attack of the disease, but cases of a second attack have been reported. *Age incidence*

The incubation period is probably 3 weeks or less, and the period of maximal infectivity is the first few days of the disease. Isolation for 3 weeks from the onset of the disease is advised by most authorities. *Incubation* *Isolation*

3. MORBID ANATOMY

Pericellular and perivascular lymphocytic infiltration is found in the affected parts of the central nervous system. At one time this was considered to be limited to the motor cells of the anterior horns of the spinal cord, but changes have been found to occur in many parts of the central nervous system, such as the brain-stem, the posterior nerve roots and the sympathetic system.

4. CLINICAL PICTURE

According to the part of the central nervous system most affected poliomyelitis has been divided into different types: meningeal or non-paralytic, spinal, myelitic and encephalitic. In the acute stage there may be fever up to 102° F. or higher, sore throat, irritability, headache, vomiting, backache, pain in the limbs, muscle tenderness and spasm, stiffness of the spine with inability to "kiss the knees", positive Kernig's and Brudzinski's signs and absence of tendon reflexes. In some cases these signs and symptoms may be very slight and only a few of them may be present. Should paralysis occur, it usually appears 2 or 3 days after the onset of the disease and is of the flaccid type; rarely, a spastic paralysis develops at a later date. Involvement of the cranial nerves may also be present and sometimes is the only paralytic sign. *Signs and symptoms*

5. SPECIAL AIDS TO DIAGNOSIS

Lumbar puncture should be carried out in all cases of suspected poliomyelitis. The cerebrospinal fluid is usually under a moderately increased pressure (150–200 millimetres of water); it shows, typically, an increase of cells up to 300 per cubic millimetre, and in the early stage of the disease these may be almost exclusively polymorphonuclear, but most specimens show at least 50 per cent of lymphocytes. Protein is raised and this rise usually increases after the cellular content has started to fall. The levels of chlorides and of sugar are normal. *Lumbar puncture*

6. DIFFERENTIAL DIAGNOSIS

(1) Pyogenic meningitis

This may be primary or secondary; in the latter case a primary septic focus, such as an acute mastoiditis, may be found. Examination of the cerebrospinal fluid will determine the infection by the discovery of the causal organism. The fluid will be cloudy and will contain a large number of polymorphonuclear cells. The sugar content will be diminished or absent.

(2) Tuberculous meningitis

The onset of the disease may be gradual, and indefinite symptoms will usually have been present for 2 or 3 weeks. Examination of the cerebrospinal

fluid will show a lymphocytosis and an increase in the protein content, but the chloride level will usually be subnormal and tubercle bacilli may be found.

(3) Acute benign lymphocytic meningitis

In some cases it may be very difficult to differentiate this condition from poliomyelitis, but cerebrospinal fluid cell-counts of 500 per cubic millimetre are not uncommon. In the type complicating glandular fever the Paul-Bunnell test will be positive.

Paul-Bunnell test

(4) Acute polyneuritis

Differential diagnosis may sometimes be difficult, but the onset is usually more gradual than in poliomyelitis and the paralysis is typically symmetrical, peripheral, and associated with well-marked sensory changes. The cerebrospinal fluid may show an increased protein content.

(5) Acute myelitis

There is symmetrical paralysis with corresponding sensory changes. At first the tendon reflexes are lost, but the plantar responses are extensor and the immediate flaccid paralysis becomes spastic.

(6) Syphilitic epiphysitis or pseudo-paralysis

This occurs in infants, and other signs of syphilis will be present. The Wassermann reaction will be positive.

(7) Acute osteomyelitis

The pain and tenderness are most marked on percussion of the affected bone. Swelling of the neighbouring joint may be present.

(8) Rheumatic fever

The pain is in the joints themselves, and effusions may be present. There is always some evidence of cardiac involvement.

7. PROGNOSIS

The immediate prognosis as to life depends upon the site of the disease; thus, involvement of the respiratory centre is invariably fatal. Apart from this, bilateral laryngeal abductor paralysis may be fatal unless tracheotomy is performed promptly. Involvement of the respiratory muscles may be complicated by pulmonary infection, and prolonged gross paralysis of the respiratory musculature may, in spite of treatment of the patient in an "iron lung", result in cardiac failure.

As far as the motor paralysis is concerned, cranial nerve involvement almost always ends in complete recovery. Recovery from spinal nerve paralysis is most rapid and most complete during the first 6 months after the onset of the disease; subsequent to this further recovery may occur but at a slower rate and to a lesser extent. If a muscle or limb that has been adequately treated is still completely paralysed at the end of 6 months no useful recovery is likely to occur. Sometimes in small children unexpected improvement of a paralysed muscle may occur after an interval much greater than 6 months. This can be explained by the inability to obtain the necessary co-operation from small children in the active part of their treatment.

8. TREATMENT

In the early stage while fever is present, local heat should be applied if there is much muscle tenderness or spasm. This heat can take the form of hot flannels, hot bottles, or an electric blanket or pads. *Heat*

It is important to make a careful muscle examination in order to determine the degree and site of any paralysis. This examination should be recorded on a muscle chart preferably using the terminology recommended by the Medical

LEFT LEG	CONTRACTURES	RIGHT LEG
	Hip	
	Knee	
	Ankle	
	Foot and Toe	
	Date	
	MUSCLE POWER	
	Facial	
	Neck	
	Back	
	Respiration	
	Quadratus Lumborum	
	Anterior Abdominals	
	Lateral Abdominals	
	Gluteus Maximus	
	Sartorius	
	Hip Flexors	
	Inward Rotators	
	Outward Rotators	
	Adductors	
	Abductors	
	Tensor Fasciae Femoris	
	Quadriceps	
	Hamstrings, Inner	
	" Outer	
	Calf	
	Tibialis Posticus	
	Flexor Long Digit.	
	" " Hallucis	
	Tibialis Anticus	
	Extensor Long Digit.	
	" " Hallucis	
	Peronei	
	Short Muscles of Foot	
	Length of Limb	

Strength of Contraction. 0 No contraction
1 Muscle contracts, no movement produced
2 Produces movement not against gravity
3 Contracts against gravity only
4 Contracts against gravity and resistance
5 Normal contraction

FIG. 42.—Muscle chart for lower limbs, used to determine the site and degree of paralysis.

Research Council in the examination of peripheral nerve injuries (Figs. 42 and 43).

At first the patient should be kept in the recumbent position; if there is weakness of an upper limb a pillow should be placed in the axilla to keep the arm partially abducted, and if the lower limbs are involved a pillow should be placed under the knees and a foot-board with a pillow over it against the feet. A cradle should always be used to prevent pressure by the bed-clothes.

Splinting For small children it is necessary to use some form of temporary splinting for the upper limb as soon as any paralysis of the shoulder girdle is detected. This can easily be made from padded Cramer wire-splinting.

LEFT ARM	CONTRACTURES	RIGHT ARM
	Shoulder	
	Elbow	
	Wrist	
	Fingers	
	Date	
	MUSCLE POWER	
	Trapezius	
	Rhomboids	
	Shoulder Out. Rotators	
	" In Rotators	
	" Adductors	
	" Extensors	
	Pect Maj Sternal Head	
	" " Clavic. Head	
	Deltoid Anterior Fibres	
	" Posterior Fibres	
	Biceps	
	Brachialis Anticus	
	Triceps	
	Brachio-rad (Supinator)	
	Extensor Carpi Ulnaris	
	" " Rad	
	" Communis Digit.	
	" Indicis	
	" Longus Poll	
	" Brevis Poll	
	Abductor Long Poll	
	Pronator Rad Teres	
	Flexor Carpi Radialis	
	" " Ulnaris	
	" Prof Digit	
	" Sublim Digit.	
	" Long Poll	
	Abductor Brev Poll	
	Opponens Pollicis	
	Flexor Brev Poll	
	Lumbricales	
	Interossei Dorsal	
	" Palmar	
	Small Musc Little Finger	
	FUNCTION	
	Opposition of Thumb	
	Grasp	
	Closure of Fist	

FIG 43 —Muscle chart, as in Fig 42, for upper limbs.

Respiratory embarrassment If the intercostal muscles, or diaphragm, are involved respiratory embarrassment may occur, and it may then be necessary to place the patient in a respirator or "iron lung", either a Drinker or a Both apparatus (Fig. 44) If an "iron lung" is not available, nasal oxygen and artificial respiration may tide over an emergency.

Tracheotomy Very occasionally tracheotomy is required when there is bilateral laryngeal abductor paralysis. Sometimes the respiratory passages may become impeded by secretions. The head of the "iron lung" should then be lowered and the mucus removed by suction; retention of pulmonary secretions is very liable

Retention or incontinence of urine may occur early in the disease, and in the former catheterization will be required. In either case Sulphamezathine (1 gramme 4-hourly) should be given, particularly when retention is present.

FIG. 44—Patient in a Both respirator or "iron lung". The machine is shown partly open.

(1) Physiotherapy

Active physiotherapy should be started as soon as the temperature is normal, although the treatment may have to be modified when muscle tenderness persists. The treatment consists essentially of heat, massage, passive movements of all the joints of the affected limbs and active exercises. Electricity is of little value except, perhaps, interrupted galvanism to the intrinsic muscles of the hands when these are involved, and, in the later stages, faradism combined with exercises, in order to obtain the maximal development of a partially paralysed muscle or muscle group. Splinting is indicated when there is unbalanced muscle weakness, for example, if the invertors of a foot are paralysed and the evertors are strong; it may also be required when there is weakness of important muscles, such as the abductors of the hip. Such splints should never be worn for the whole 24 hours; they should be removed completely for treatment, and for several hours each day, but it may be necessary for them to be worn throughout the night. Treatment should be given daily, and if possible should be spread out during the day so that the patient does not become exhausted by having it all at one long session. When the patient is old enough, exercises should be carried out, in part, at least, by means of pulleys, slings and springs suspended from an overhead apparatus, such as a Balkan beam or the Guthrie Smith apparatus. Ideally the suspension apparatus should be fixed rigidly to the bed so that exercises can be carried out at frequent intervals with as little disturbance to the patient as possible. In addition to the above, the use of the warm-water pool is of great value as it combines heat with the elimination of gravity.

Galvanism

Faradism

Warm-water pool

It is sometimes found that a patient who has involvement of the respi muscles, and who is in an "iron lung", is difficult to wean from this ap tus, in such cases the use of the Paul-Bragg *respirator will often help* 45). The Paul-Bragg apparatus, when it is used as a method *of physical* ment, is also of benefit to patients who have some *partial paralysis*

Paul-Bragg respirator

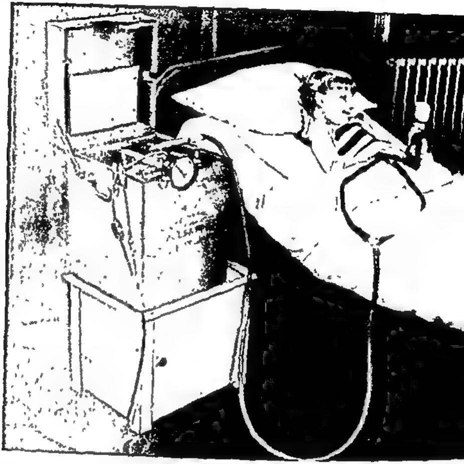

FIG 45.—Paul-Bragg respirator.

respiratory muscles. The apparatus is put on for some hours each day in ord to rest these muscles.

(2) *Stabilization* of the paralysed limb

It is obvious that the essential functions of the upper and lower limbs ar very different. In the upper limb, dexterity of movement, particularly of fin movements of the hand and fingers, and normal sensation, are of prim importance whereas in the lower limb stability is all-important for, to give i its lowest value, the lower limb is a living prop on which to stand or walk.

Intentional equinus deformity

The necessary stability of the lower limb can be obtained by means of exter nal splints, by operation or, occasionally, by intentional acquisition of a moderate equinus deformity of the ankle. To understand the last named, one must appreciate that stability of a knee uncontrolled by muscles can occur only when that joint is "locked" by the centre of gravity passing in front of the centre of the fully extended joint. Use is made of this elementary fact in

the design of the above-knee artificial limb, in which the ankle joint is in slight equinus and the amputee is trained to extend his stump fully when walking and transferring his weight on to the artificial limb. Similarly, in a partially paralysed lower limb when there are strong hip extensors and calf muscles, walking may be accomplished successfully without any instrument and with little limp, even though the knee muscles are paralysed, provided that there is some equinus deformity of the ankle.

Stabilizing operations

The commonest type of operation is some form of arthrodesis and is of particular value in the foot, although it is generally agreed that it should not be carried out before the patient is 12 years old, since before that age there is inadequate ossification of the tarsal bones, which are often abnormally small and decalcified in poliomyelitis.

Triple arthrodesis

The basis of all foot arthrodeses is the triple arthrodesis in which the sub-astragaloid, astragalo-scaphoid and calcaneo-cuboid joints are fused. In the flail foot or drop foot with an acting calf muscle, however, such a simple arthrodesis leaves too long a lever in front of the ankle joint; this can be counteracted by performing a Dunn's arthrodesis, in which the scaphoid is excised and the foot displaced backwards, or by carrying out an operation which involves the formation of a posterior bony block to prevent plantar flexion or by the use of a normal bony structure for this purpose. Of the former type of procedure there is the Campbell bone block operation, and of the latter type, Lambrinudi's drop foot arthrodesis in which the posterior tubercle of the astragalus is used as a block to plantar flexion.

Tendon transplantation

Tendon transplantation can also be combined with the triple arthrodesis in certain cases when there is an unbalanced foot; for example, the peronei can be transplanted to the dorsum to take the place of paralysed dorsiflexors or they can be transplanted posteriorly to reinforce a weak calf muscle.

Arthrodesis of knee

Arthrodesis of the knee is rarely indicated in the paralysed limb since a long walking instrument with a locking knee joint is usually much more convenient than a permanently stiff knee which is a real disability to a person who is sitting most of the day; it will be appreciated that the majority of persons disabled by poliomyelitis who can earn their living, do so in sedentary occupations.

Arthrodesis of hip

Instability of the hip joint on account of paralysis causes an ugly lurching gait. In certain cases this can be considerably improved—and instruments discarded—by performing an arthrodesis of the hip joint, provided that the muscle power of the other leg is normal or nearly so. The arthrodesis should be intra-articular combined with a graft or a long Smith-Petersen nail; arthrodesis by means of a long nail alone is usually unsatisfactory as in time it tends to work loose.

Arthrodesis of shoulder

In the upper limb stabilizing operations are much less frequently needed than in the lower limb. Arthrodesis of the shoulder joint is sometimes indicated when the scapular muscles are strong but the abductors are paralysed, but it is often found that the function, even with a paralysed deltoid muscle, is so good that a stabilizing operation is not justified.

Arthrodesis of the elbow joint is rarely required in poliomyelitis, but when the flexors are paralysed transplantation of the flexor group of the forearm

if strong, to the internal intermuscular septum of the arm—the Steindler slide operation—will, in certain cases, vastly improve the function of the limb.

Arthrodesis of wrist

At the wrist, arthrodesis is sometimes required when the dorsiflexors are paralysed. When active opposition of the thumb is absent, an intermetacarpal graft, by the insertion of a portion of tibia, about 1 inch by 1½ inches in size, into slots in the shafts of the first and second metacarpals, so placed that the thumb is in opposition, will markedly improve the function of the hand.

REFERENCES

Rosenow, E. C. (1944) *Lancet*, 1, 491.

[References to other titles are given under Poliomyelitis in the Index Volume. The subject is also dealt with under the heading of Poliomyelitis and Polioencephalitis in the *British Encyclopaedia of Medical Practice* (1938), Vol 10, p. 12.]

POLYCYSTIC DISEASE

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1. DEFINITION

275.] The term, polycystic disease, is applied to the pathological condition in which multiple cysts are present in one or more of the viscera. The kidney most often presents this abnormality, but the lungs, liver, pancreas and brain are occasionally affected. Not infrequently more than one of these organs exhibit the polycystic state simultaneously. In paired organs, the condition is commonly bilateral, though one side may be affected more severely than the other.

Site of cysts

2. AETIOLOGY

A large proportion of cases of polycystic disease, especially of the kidneys, are recognizable in infancy, the condition having apparently arisen as an error of development in early intra-uterine life. The belief in a developmental origin is supported by the frequent association of polycystic disease of one or more of the viscera with such structural abnormalities as polydactylism, anencephaly, meningocele, stenosis of the ureters or occlusion of the urethra. Moreover, in many cases, the condition possesses a familial incidence; polycystic disease of the kidneys has been recorded by Fuller (1928–29) in four generations of one family, and a number of pedigrees showing multiple cases of polycystic disease of the liver and pancreas have also been reported. Lindau's disease, in which cysts are present in the cerebellum, is also commonly familial and may be associated with polycystic disease of other organs, notably the pancreas.

Developmental origin

Possible familial incidence

3. MORBID ANATOMY AND HISTOLOGY

The morbid anatomical features of the affected viscera are distinctive and they will therefore be considered individually.

(1) Kidney

The kidneys are usually much enlarged, sometimes to eight or ten times their normal weight, by the presence of enormous numbers of cysts of widely

varying size. Some cysts are barely visible to the naked eye, whereas others may be several centimetres in diameter. The sacs, as seen through the bulging capsule, appear translucent and colourless or opaque and brownish. On longitudinal section of the kidney, the cysts can be seen to be distributed more or less uniformly throughout the organ, though those in the cortex are usually rather smaller than are those more deeply placed. Between the cysts, and firmly compressed by them, can be seen the small masses of residual renal substance. These masses, though individually small, are numerous, and collectively they may maintain adequate excretory functions for many years. The cysts are smooth-walled and usually contain a colourless, clear, though sometimes viscous and turbid, fluid; not infrequently their contents become amber yellow or even chocolate brown due to the haemoglobin degradation products derived from small haemorrhages into their interior.

Longitudinal section

Histology

Histologically, the cysts are lined by cubical or low, flattened epithelium, beneath which is a thin layer of connective tissue. In patients dying from renal failure, the remaining nephrons are often distorted by pressure from neighbouring cysts; it is the progressive destruction of this parenchyma, through interference with its vascular supply, and its ultimate replacement by fibrous tissue, that eventually causes death in most cases.

Glomerular or tubular cysts

Serial sections, supplemented by appropriate wax-model reconstructions, taken from polycystic kidneys of new-born infants and middle-aged adults, have shown that the cysts may be either glomerular or tubular. In the former type, a glomerulus is either present in the wall of the cyst or connected with it by a short intervening tubule. In the latter, the cyst forms in a portion of the tubule—that is, in any portion of the nephron from the proximal convoluted tubule to the collecting tubule—which has become entirely separated from its glomerular connexion. Reconstructions, made from the kidneys of infants, show that the cysts never connect with any of the collecting tubules and are thus closed vesicles but, in adults, some of the cysts may open into lower excretory tubules and eventually into the renal pelvis. In spite of its distorted morphology, this latter type of cyst may retain, to a limited degree, some of its excretory functions. It is this difference between the completely closed cysts of the non-viable infant and the partially open cysts of the adult that has made it possible for the latter to survive into middle life before renal failure develops (Lambert, 1947).

(2) Lung

Congenital origin

Apart from emphysematous bullae, which have a typical distribution, intrapulmonary cysts are usually congenital. Sometimes smooth-walled cystic cavities arise, following tuberculosis and other chronic infections, but their apical location is usually characteristic.

Congenital cysts may be single or multiple; the former may attain a diameter of many centimetres, and may gravely embarrass respiration especially in infancy. When multiple, the cysts are of smaller size, ranging in diameter from 2 or 3 centimetres downwards, and they are generally restricted in distribution to one lung or even to a single lobe; of the 371 cases in Schenck's collected series (1937), only 78 showed a bilateral distribution of the cysts. Unless they have become infected—which is a common sequela—congenital cysts have smooth, glistening walls. Usually they are unilocular, but

sometimes, possibly through the partial fusion of one or more cysts, they are multilocular. At birth and in early infancy the cysts are often filled with milky fluid, but later they generally contain air, and their continuity with a small bronchus can usually be demonstrated without difficulty. *Unilocular and multilocular cysts*

Histologically, uninfected cysts are lined by a single layer of epithelium, which is often ciliated and continuous with that of the entering bronchus. This epithelium lies on a thin layer of connective tissue which alone separates it from the surrounding, partially compressed, lung substance. The normal muscular layer and the cartilaginous plates of the entering bronchus usually terminate at the level at which the cyst arises (Sellors, 1938). *Histology*

(3) Liver

Polycystic disease of the liver is relatively rare and, when present, is almost invariably associated with a similar abnormality in the kidneys. In infancy, the liver is little enlarged by the cysts, which are small and of irregular shape, and are apparent only when the organ is closely examined and sectioned at necropsy. In adults, in whom the condition has probably been present since birth, the liver is usually moderately, and sometimes greatly, enlarged, the degree depending mainly on the number of cysts present. The cysts tend to be distributed at random throughout the organ, and often they can be seen as translucent sacs lying just beneath its capsule. In severe cases the whole liver may be diffusely honeycombed with large numbers of smooth-walled cavities—many of them several centimetres in diameter—which generally contain clear albuminous fluid. Occasionally, the fluid contains the brown degradation products of haemoglobin, but it is never stained with bile; this feature indicates the separation of the cysts from the residual functional bile-ducts. *An associated condition*

From histological examination of small cysts, it appears that they arise from the proliferation of the bile-duct epithelium in the smaller portal canals, for they are lined with characteristic cubical epithelium. When examined in serial section, however, such dilated ducts can be traced to terminations in solid uncanalized strands of similar epithelial cells. In adults, in whom the cysts are larger and more regularly globular in form, the epithelium has assumed a more flattened, less differentiated, character, and the enclosing capsule of fibrous tissue has become thicker and denser. In spite of the disturbances created by these multiple cysts, however, the main mass of the liver parenchyma cells seem to be little affected either morphologically or functionally. *Histology*

(4) Pancreas

Grossly recognizable congenital cysts of the pancreas are rare, and comprise only a small minority of the several varieties of cyst that are found in association with this organ. On the other hand, congenital fibrocystic disease, in which the cysts are of microscopic size, is becoming increasingly recognized by paediatricians as a cause of pancreatic insufficiency and steatorrhoea (Anderson, 1938; Wiglesworth, 1946). Even when they are macroscopic, however, congenital pancreatic cysts seldom reach any large size, and the organ itself is scarcely enlarged by their presence. When they are multiple, as is usual, the cysts are distributed at random throughout the viscus. The lining of their walls is smooth, and they contain a thin mucous fluid, though *Limited enlargement of pancreas*

varying size. Some cysts are barely visible to the naked eye, whereas others may be several centimetres in diameter. The sacs, as seen through the bulging capsule, appear translucent and colourless or opaque and brownish. On longitudinal section of the kidney, the cysts can be seen to be distributed more or less uniformly throughout the organ, though those in the cortex are usually rather smaller than are those more deeply placed. Between the cysts, and firmly compressed by them, can be seen the small masses of residual renal substance. These masses, though individually small, are numerous, and collectively they may maintain adequate excretory functions for many years. The cysts are smooth-walled and usually contain a colourless, clear, though sometimes viscous and turbid, fluid; not infrequently their contents become amber yellow or even chocolate brown due to the haemoglobin degradation products derived from small haemorrhages into their interior.

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in the fibrocystic form the microscopic cysts often enclose small hard concretions which give rise to a harsh grating sound when the organ is incised.

Histology

Histologically, in both varieties there is an exaggerated development of the ducts, and it is from segmented portions of these that the cysts appear to arise. Generally, there is widespread interstitial fibrosis throughout the organ, and the exocrine acini are greatly reduced in number; the islets of Langerhans, however, seem to be little affected.

(5) Brain

Cysts arise in the brain either as a result of degenerative changes in gliomas or in conjunction with haemangiomas (Lindau's disease). In this latter condition, one cyst, rarely more, develops in the cerebellum or medulla oblongata; supratentorial cysts of this nature are extremely rare. The cysts tend to be small and usually lie in the cortical zone of the lateral and posterior parts of the cerebellum. On section, they are seen to be enclosed by a grey or greyish-red capsule, though the innermost layer is sometimes bright yellow as a result of the accumulation of the degradation products of the blood, haematoidin and haemosiderin. The walls of the cysts are smooth, and they are generally filled with a clear or slightly opalescent, pale-yellow fluid; occasionally their contents are blood-stained, due to the leakage of small quantities of blood from the neighbouring angioma.

Accumulation of blood degradation products

Histology

Histologically, these cerebellar cysts lack an important feature of true cysts, for, as Lindau pointed out (1926), they are lined neither by epithelium nor by endothelium, but are merely rounded spaces surrounded by haemangioma vessels and compressed neuroglia. Often the smaller blood-vessels in the angioma are devoid of blood, so that the cyst wall appears strikingly cellular and its true nature not immediately apparent; small giant cells and foamy xanthoma cells are often present in the cyst wall.

4 PATHOGENESIS

(1) Kidney

Various theories have been advanced for the development of polycystic kidneys, but none has yet received general acceptance. Originally, Virchow (1863) suggested that the cysts arose from tubules which had become obstructed during foetal life, as a result of some local inflammation, but this view has now been abandoned because the sequelae of such inflammatory reactions can seldom be recognized subsequently, in any case this explanation would fail to account for the frequent familial incidence of polycystic disease and its simultaneous occurrence in several of the viscera. Nor is there serious support today for the neoplastic theory of these cysts; to classify them, as did Herxheimer (1913), as hamartomas, fails to advance our knowledge of their pathogenesis. Since the discovery of the dual origin of the embryonic kidney, most theories have centred round the possible failure in proper development and union of its two primary tubular systems—the nephrons proper and the collecting tubules—with consequent cyst-like distension of the former. There are, however, important difficulties in accepting this explanation. First, the interruption in the tubular lumen does not always take place at the normal site of union of the two systems, but may be situated at any point along the entire course of the nephron. Secondly, in individuals who survive into adult

Rejection of neoplastic theory

life, occlusion of the affected nephrons is not always present—the cyst sometimes being in anatomical and functional communication with a collecting tubule. Thirdly, cysts of an apparently similar character often occur simultaneously in the liver and pancreas, in which organs the union of two *anlagen* does not take place. It must be admitted that at present there is no satisfactory explanation for the development of these multiple cysts.

(2) Lung

These cysts seem to arise through a failure in the development of the muscle and cartilage—the normal supporting elements—in the walls of some of the smaller bronchi. In consequence, the terminal portions of the defective bronchi, together with their associated atria and alveoli, become distended into cysts.

Failure in development of muscle and cartilage

(3) Liver and pancreas

The formation of cysts is associated in both these organs with an apparently excessive production of duct epithelium during late foetal life. Subsequently, degenerative changes set in, but they fail to bring about the complete disappearance of all the redundant ducts (Norris and Tyson, 1947). Surviving portions of the ramifying duct system become segmented and provide clefts and spaces, lined with epithelium, which later become distended by their own secretions into cysts containing fluid.

Proliferation of duct epithelium in foetus

(4) Brain

The angiomas, with which the congenital cerebellar cysts are associated, seem themselves to be of congenital origin, for they often occur together with angiomas of the retina (Hippel's disease) and with polycystic disease of the pancreas and kidney. Nearly a quarter of the cases of Lindau's disease have been familial. In the cerebellum, the angioma appears to be the initiating abnormality, and it seems likely that the cyst arises as a result of the excessive transudation of fluid through its thin-walled blood-vessels. The local accumulation of this fluid forces aside and compresses the surrounding neuroglia and creates the cyst cavity. Not infrequently there is a history of trauma preceding the formation of the cyst, so that the tissue cleft which later becomes distended, may well start as a small haemorrhage.

History of trauma

BIBLIOGRAPHY AND REFERENCES

Anderson, D. H. [illegible]

Fuller [illegible]

Herxh [illegible] *Menschen und der Tiere*, ed by Schwalbe, E. Part III, 10th ed., Suppl., chap 2, p. 201 Jena; Fischer.

Lambert, P. P. (1947) *Arch. Path.*, 44, 34.

Lindau, A (1926) *Acta path microbiol scand.*, Suppl 1

Norris, R. F., and Tyson, R. M. (1947) *Amer. J. Path.*, 23, 201.

Rolleston, H. D., and McNee, J. W. (1929) *Diseases of the Liver, Gall-Bladder and Bile-Ducts*, 3rd ed., p. 55. London; Macmillan.

Schenck, S. G (1937) *Arch intern. Med.*, 60, 1.

Sellors, T. H. (1938). *Tubercle, Lond.*, 20, 49, 114.

Virchow, R. (1863) *Die Krankhaften Geschwulste*, Vol. 1, p. 270 Berlin; Hirschwald

Wiglesworth, F W. (1946) *Amer. J. med. Sci.*, 212, 351.

[References to other titles are given under Polycystic Disease in the Index Volume]

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The formation of cysts is associated in both these organs with an apparently excessive production of duct epithelium during late foetal life. Subsequently, degenerative changes set in, but they fail to bring about the complete disappearance of all the redundant ducts (Norris and Tyson, 1947). Surviving portions of the ramifying duct system become segmented and provide clefts and spaces, lined with epithelium, which later become distended by their own secretions into cysts containing fluid. *Proliferation of duct epithelium in foetus*

(4) Brain

The angiomas, with which the congenital cerebellar cysts are associated, seem themselves to be of congenital origin, for they often occur together with angiomas of the retina (Hippel's disease) and with polycystic disease of the pancreas and kidney. Nearly a quarter of the cases of Lindau's disease have been familial. In the cerebellum, the angioma appears to be the initiating abnormality, and it seems likely that the cyst arises as a result of the excessive transudation of fluid through its thin-walled blood-vessels. The local accumulation of this fluid forces aside and compresses the surrounding neuroglia and creates the cyst cavity. Not infrequently there is a history of trauma preceding the formation of the cyst, so that the tissue cleft which later becomes distended, may well start as a small haemorrhage. *History of trauma*

BIBLIOGRAPHY AND REFERENCES

Anderson, D. H. (1938) *Amer. J. Dis Childh.*, 56, 344.

Fuller, C. J. (1928–29). *Quart. J. Med*, 22, 567.

Herxheimer, G (1913). *Die Morphologie der Missbildungen des Menschen und der Tiere*, ed by Schwalbe, E. Part III, 10th ed, Suppl, chap 2, p. 201 Jena; Fischer.

Lambert, P. P. (1947) *Arch Path.*, 44, 34.

Lindau, A (1926). *Acta path microbiol. scand.*, Suppl 1.

Norris, R. F, and Tyson, R. M. (1947). *Amer. J. Path.*, 23, 201.

Rolleston ... *ses of the Liver, Gall-Bladder and* ... n.

Scho ...

Sello ...

Virchow, R. (1863) *Die Krankhaften Geschwulste*, Vol. 1, p. 270. Berlin; Hirschwald.

Wiglesworth, F. W. (1946). *Amer J. med Sci*, 212, 351.

[References to other titles are given under Polycystic Disease in the Index Volume]

POST-OPERATIVE GANGRE

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1. DEFINITION

276.] This article deals only with the form of post-operative gangrene as progressive bacterial synergistic gangrene, in which there is simul invasion of the tissues by a micro-aerophilic non-haemolytic strept and a *Staphylococcus aureus*.

2. HISTORY

Though seen and recorded previously as one of the types of hospit grene, the first descriptions of this condition as a clinical entity cam America in 1924 when Cullen and Christopher separately described cases, the former recording an ulceration of the abdominal wall after dicectomy, and the latter a similar condition of the chest wall follow resection for drainage of an empyema.

Stewart-Wallace (1935) collected and discussed the cases which ha been reported. It is to Meleney (Meleney, 1931 and 1933; Meleney, Fri

and Harvey, 1945; Brewer and Meleney, 1926), however, that we owe most of our knowledge of the condition and its cause. Its incidence is rare but world-wide. *Incidence*

3. AETIOLOGY

Nearly all reported cases, with the rare exception of those of so-called spontaneous onset (Luckett, 1909; Kappis, 1932; Callum and Duff, 1941), have followed surgical intervention in cases of appendicitis, perforated peptic ulcer, cholecystitis, the drainage of an abdominal abscess, gut resection and other operations involving possible contamination of the wound by intestinal organisms; or they have followed the drainage of a lung abscess or foetid empyema when anaerobic organisms have been present. *After surgical intervention*

The incision and suturing of the wound implant the streptococcus in its anaerobic environment. It is possible, though unlikely, that a wound not exposing infected material might become contaminated with the responsible organisms either from the air or from the patient's skin. Two cases have been reported following suprapubic prostatectomy (Bassow, 1945). A towel clip has been held responsible in one case (Lichtenstein, 1941). *Source of streptococcus*

The source of the staphylococcus is the air of the operation theatre or the ward, the respiratory passages of the attendants, or the skin of the patient. *Source of staphylococcus*

Though the infection has not been reported in infants and children, age has no bearing on incidence, nor has the general state of health and nutrition of the patient.

Ballin and Morse (1931) considered their case to be an example of the Arthus type of hypersensitivity reaction, a phenomenon of cutaneous necrosis seen after the injection of bacterial and protein products in a sensitized animal. *Phenomenon of Arthus*

Without further proof, the destructive effect of the infection should be considered to be the direct action of the combined products of metabolism of the organisms on the living cells of the tissues.

4. BACTERIOLOGY

Brewer and Meleney (1926) first demonstrated the two responsible organisms and, by experimental animal inoculation, the synergistic action of the combined infection. Meleney (1931), Nightingale and Bowden (1934), and Willard (1936) confirmed these findings. *Synergistic action of combined infection*

(1) The streptococcus

The streptococcus is always to be found at the edge of the ulcer, on the surface or invading the tissues, a biopsy specimen of the margin being taken, if necessary, to demonstrate it. Its presence will be missed unless anaerobic cultures are made. The organism is a normal inhabitant of the human gut. A good account of the coccus has been given by Prèvot (1925) who showed that, after artificial culture, it may be grown aerobically. *Necessity for anaerobic cultures*

(2) The staphylococcus

The presence of a *Staph. aureus*, which grows on aerobic culture and is usually haemolytic, has not been so consistently shown. Meleney has

demonstrated it in his cases, but the *staphylococcus is often present* (small numbers and is easily overgrown on culture (Brewer and Me 1926; Meleney, 1931 and 1933).

Simple contaminants

The presence of other organisms is frequently recorded; they probably as simple contaminants.

5. PATHOLOGY

Bacterial synergistic gangrene results in a progressive cutaneous and cutaneous *ulceration and does not penetrate* intact deep fascia or m The advancing edge of the ulcer shows oedema in the subcutaneous ti which are heavily infiltrated with *polymorphonuclear leucocytes.* There associated hyperaemia but thrombosis in subcutaneous vessels, and hae rhagic exudates, are not seen. The purulent exudate is *plentiful but superf* overlying the base of granulation tissue.

6. CLINICAL PICTURE

(1) The onset

Early inflammatory changes

The onset of inflammatory changes is usually from 7 to 21 days afte *abdominal or a thoracic operation. It is exceptional for it to occur in the* few days, and it may be delayed for several weeks. The changes commen or near the wound, *often at the stitch holes of skin-edge or tension sutu* The wound becomes swollen and tender; it has a carbuncular appeara with a central area of indurated skin of a dull-red hue with a surroun flare of erythema.

Some days later the central area is seen to be becoming gangrenous; it is longer firm and shiny but dull and soft as it turns to a slough having appearance of grey suède leather.

(2) The developed lesion

From within outwards four characteristic zones may be seen in the fu developed lesion; there are areas of slough and intact skin at the centre s *rounded by a sea of pus-covered granulations,* extending to an angry rai dull-red scalloped margin, which fades through a zone of erythema to norr skin (Fig. 46).

Exquisite tenderness

The outstanding symptom is the exquisite tenderness of the indurated edg of the lesion, rendering frequent dressings an ordeal to the patient.

(3) The general condition of the patient

Pyrexia and polymorphonuclear leucocytosis

The general condition of the patient is not seriously affected at first. There usually a slight pyrexia and a polymorphonuclear leucocytosis. The appet remains satisfactory, the pulse steady, and there is no marked fall in t

play any part in the clinical process. A psychological depression ... if the disease is at all prolonged.

The untreated ulcer spreads daily for weeks or months until vast areas of th trunk are involved and the patient dies after an exhausting and painf illness.

Fig 46.—Skin following an empyema, in a patient with massive spreading gangrene. Treatment: diathermy ring and later a Thiersch graft. (*By courtesy of Mr. T Holmes Sellors*)

7. DIAGNOSIS

The diagnosis is based on the history of operative intervention, the progressive ulceration showing the typical zones, and the finding of the causative organisms.

8. DIFFERENTIAL DIAGNOSIS

Smears and cultures

In all severely infected wounds smears should be stained, and cultures made, from the exudate at the margin, from the central slough if such has formed, and from the depths of the wound Cultures should be grown anaerobically as well as aerobically.

(1) Common wound infections

Such infections, leading to abscess formation or cellulitis, will readily be distinguished by their clinical progress and the finding of the causative organism.

(2) Specific infections

Specific infections by *Corynebacterium diphtheriae*, tubercle bacilli, blastomycotic and actinomycotic organisms, or the Donovan bodies of granuloma inguinale, may require elimination. The responsible organism can usually be identified if careful search is made. Erysipelas is unlikely to cause confusion.

(3) Gas gangrene

Whether clostridial or due to anaerobic streptococci, gas gangrene is more likely to be seen in surgery of the limbs. It may be seen after abdominal or perineal operations, by contamination from the alimentary tract. Its onset is earlier, and the condition is more rapid in its progress and causes a more severe systemic disturbance. The causative organism is easily found in the discharge from the wound.

(4) Haemolytic streptococcal gangrene

First described by Meleney (1924) and Jen (1929), this condition is a more acute cellulitis of the subcutaneous tissues, usually following superficial wounds. There is extensive sloughing of fat and a patchy gangrene of the overlying skin. There is often a blood-stream infection and metastatic foci may develop. After the administration of penicillin or sulphonamides, surgical intervention is required to relieve tension and evacuate exudate and slough.

(5) Fournier's gangrene

This is a spontaneous gangrene of the skin of the scrotum or vulva due to a haemolytic aerobic streptococcus (Campbell, 1922).

(6) Gangrenous impetigo

Gangrenous impetigo is unlikely to be mistaken for synergistic gangrene, though Brunsting, Goeckerman and O'Leary (1930) describe a case with extensive gangrene of the abdominal wall in a patient debilitated by ulcerative colitis.

(7) Cutaneous amoebiasis

First described by Nasse in 1892, Wyatt and Buchholz (1941) could collect only 28 proven cases of cutaneous amoebiasis up to 1939. Engman and Meleney (1931) have presented a classification which has been accepted; Wilson and Hurewitz (1946) and Mahadevan (1945) discuss the problem.

Drainage of an amoebic abscess, or abdominal and perineal operations on infected gut, may be followed by a slowly spreading cutaneous gangrene similar to that seen in synergistic gangrene, except that no islands of intact skin remain in the ulcerated area and the ulceration may penetrate fascia and muscle. The *Entamoeba histolytica* can be identified in scrapings from, or histological sections of, the margin of the ulcer. The condition usually responds readily to a course of emetine, though secondary bacillary infection

Treatment with emetine

may require preliminary or additional treatment. Owing to the wide dispersal of troops and their attendants in recent years, chronic or latent amoebiasis may unexpectedly be brought to light post-operatively, unless the possibility is borne in mind and the stools are carefully examined pre-operatively.

(8) Chronic undermining ulcer (Meleney, 1935)

The infecting organism in this condition is a micro-aerophilic haemolytic streptococcus alone. The lower abdominal and pelvic superficial tissues are the commonest site though the infection may follow wounds and incisions elsewhere. A slowly spreading subcutaneous infection eats its way through the tissues with little local or systemic reaction at first, and without producing any slough. It spreads widely, leaving numerous rounded or cribriform undermined ulcers in the skin. It has not proved readily responsive to chemotherapeutic agents which must, however, be given in large doses for long periods. A small lesion may be excised. Repeated and thorough application of 5 per cent medicinal zinc peroxide paste may cause the lesion to regress.

Commonest site

Zinc peroxide paste

(9) Fuso-spirochaetal infections

Such infections form foul sloughing lesions with local invasion even to bone and with multiple sinus formation. Spirochaetes, spirilla, fusiform bacilli and streptococci can be identified. Bite wounds inflicted by human beings are the common source of infection. Cancrum oris and noma are other manifestations. Débridement, and the administration of neoarsphenamine and penicillin are required in treatment.

(10) Myiasis

Infestation of wounds by the larvae of certain diptera, unless recognized and eradicated, may lead to extensive destruction of tissue and even to death.

9. PROGNOSIS

Many cases have proved fatal in the past as a result of late recognition and inadequate treatment. The lesion is usually slowly progressive, though Callum and Duff (1941) report a death 21 days after appendicectomy. Spontaneous cure has been reported but is not to be expected.

Slowly progressive lesion

Dodd, Heekes and Geiser (1941), after reviewing the literature, placed the mortality at 20 per cent. With adequate bacteriological investigation of wound sepsis, the ready use of penicillin, and the early use of the knife if this fails, there is no reason why any life should be lost from this form of post-operative wound gangrene.

10. TREATMENT

(1) Prophylactic

Prophylaxis demands that the soiling and contamination of wounds at operation be avoided as far as possible. Unnecessary sutures should never be inserted, tension sutures having a particularly bad record in the production of synergistic gangrene. The local application of penicillin in a sulphonamide powder, now a common prophylactic measure, as well as the systemic

Penicillin with a sulphonamide

administration of penicillin for the originating infection, is likely to decrease the frequency with which this infection develops.

(2) Therapeutic

Penicillin

The combined anaerobic streptococcal and aerobic staphylococcal infection is usually responsive, within a few days, to the systemic administration of penicillin in average doses (Grimshaw and Stent, 1945; Meleney, Friedman and Harvey, 1945; Clarke, 1947). A clinical response may be noticed in 48 hours and a 5–7 days' course will be sufficient to see the lesion commencing rapidly to heal from the margins, and from the many islands of intact epithelium.

Excision of the margins

Occasionally an organism partially, or more completely, insensitive to penicillin will be encountered. In this event an excision of the advancing edge of the ulcer must be performed without delay. This alone is curative in the absence of penicillin.

Technique of excision

The excision should be performed with an ordinary scalpel, the diathermy knife causing unnecessary destruction of tissue. The line of excision should be at least 1 centimetre beyond the margin of the ulcer, and should pass through healthy skin and underlying oedematous subcutaneous tissue down to the deep fascia, the whole margin being raised as a ring of tissue. No attempt should be made, either by strapping or sutures, to draw the wound edges together after excision, as this favours recurrence.

Local dressings

Local dressings should be non-irritating to the tissues and painless to the patient. Penicillin cream (500–2,000 units per cubic centimetre), zinc peroxide paste if available (medicinal zinc peroxide is official in the United States [illegible]

Marsh (1947) refers to powdering the wound with potassium permanganate, and covering this with Vaseline-gauze dressings as being curative even without excision.

The following methods of treatment are either ineffective or inadvisable: the local injection of penicillin round the wound; the local or systemic administration of sulphonamides; the vigorous use of antiseptics locally; and local irradiation by infra-red, short-wave, ultra-violet or x-rays.

(3) General treatment

The general treatment of the patient is a secondary consideration. A control of the blood proteins, haemoglobin and white-cell count should be maintained. The patient requires reassurance and encouragement to assist him in combating mental depression, and analgesics to relieve his pain.

Skin grafts

When the infection has been controlled, healing is rapid. If large areas require skin cover there should not be any hesitation in applying split-skin grafts. The final scar is often lumpy, adherent and ugly but it is usually hidden, so that its excision and recovering with whole-thickness skin is rarely called for.

Streptomycin

The danger lies in having to deal with an organism which is insensitive to penicillin. Streptomycin is unlikely to be of benefit (Hirshfeld and his colleagues, 1946), and resort must then be had at once to the scalpel.

REFERENCES

Ballin, M., and Morse, P. F. (1931). *Amer. J. Surg.*, **11**, 81.
Bassow, S. H. (1945). *J. Urol.*, **54**, 46.
Brewer, G. E., and Meleney, F. L. (1926). *Ann. Surg* , **84**, 438.
Brunsting, L. A., Goeckerman, W. H., and O'Leary, P. A. (1930). *Arch. Derm. Syph., Chicago*, **22**, 655.
Callum, A., and Duff, A. (1941). *Brit. med. J.*, **2**, 801.
Campbell, M. F. (1922). *Surg. Gynec. Obstet* , **34**, 780.
[illegible] 4, 795.
[illegible]
[illegible] H. (1946). *Arch. Surg., Chicago*, **52**, 387.
Jen, T. K. (1929) *Chin. med J.*, **43**, 889.
Kappis, M. (1932) *Beitr. klin. Chir.*, **155**, 179.
Lichtenstein, M E. (1941). *Arch. Surg., Chicago*, **42**, 719.
Luckett, W. H. (1909). *Ann. Surg* , **50**, 605.
Mahadevan, R (1945). *Med. Pr.*, **214**, 317.
Marsh, F. (1947). *Lancet*, **1**, 809.
Meleney, F. L. (1924) *Arch Surg., Chicago*, **9**, 317.
— (1931). *Ann. Surg* , **94**, 961.
— (1933) *Surg Gynec. Obstet* , **56**, 847.
— (1935) *Ann Surg.*, **101**, 997.
— Friedman, S. T., and Harvey, H. D. (1945) *Surgery*, **18**, 423.
Nasse, D. (1892) *Arch klin Chir* , **43**, 40.
Nightingale, H J , and Bowden, E. C. (1934). *Brit. J. Surg.*, **22**, 392.
Prèvot, A. R. (1925) *Ann. Inst Pasteur*, **39**, 417.
Stewart-Wallace, A. M (1935). *Brit. J Surg.*, **22**, 642.
Willard, H. G. (1936) *Ann Surg* , **104**, 227.
Wilson, W. W., and Hurewitz, M. M. (1946). *Med. Clin. N. Amer.*, **30**, 411.
Wyatt, T. E., and Buchholz, R. R (1941). *Ann. Surg.*, **113**, 140.

[References to other titles are given under Post-operative Gangrene in the Index Volume]

PREGNANCY—SURGICAL INTERVENTION DURING

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1 ABNORMAL PREGNANCY AND COINCIDENTAL DISEASE

277.] When a general surgeon is called upon to operate during pregnancy the indications for such an operation fall into two classes: first, operations may be undertaken for some abnormality of the pregnancy, of which extra-uterine gestation is a good example, and secondly, operations may be required for conditions usually outside the genital tract, in which the presence of the pregnancy is incidental, and of which acute appendicitis occurring in the pregnant woman is an example.

General rules An elective operation which can be postponed until after delivery should not be undertaken during pregnancy, but because a woman is pregnant an operation for a condition actually or potentially dangerous should never be postponed. *Risk of abortion* Any operation performed during pregnancy incurs the risk of abortion. This risk is increased as the operative site comes nearer to the pregnant uterus. The liability to miscarriage or premature labour is greater in the first 3 or 4 months or in the last 3 or 4 weeks of pregnancy, so that the middle of pregnancy is relatively the safest time at which to operate. In minimizing the risk of abortion absolute rest and sedative drugs, such as phenobarbitone, opium and bromide, are the most suitable. *Progesterone* The value of progesterone is questionable. It is most likely to be useful in the early months of pregnancy and, if given at all, should be used in adequate dosage, by intramuscular injection of 10 milligrams daily during the period of risk.

Pre-operative examination Pre-operative examination must always include the estimation of the blood-pressure and examination of the urine for sugar and albumin to exclude the presence of pregnancy glycosuria and toxaemia.

Pre-operative treatment Strong purgatives and enemas are liable to produce abortion and should be avoided. If an enema is required, a small quantity of glycerin is preferable to the usual soap and water enema.

In the early months of pregnancy excessive vomiting may cause dehydration; severe hyperemesis results in chloride depletion and ketosis which require pre-operative correction. In toxaemia of pregnancy hepatic damage may be severe, and it is wise to give these patients intravenous glucose and vitamin K, especially if they are jaundiced.

Anaemia Many pregnant women suffer from a moderate microcytic iron-deficiency anaemia. As a rule this is not dangerous, but it is always a wise precaution to estimate the haemoglobin. Should blood transfusion become necessary, only *Blood grouping* blood compatible with the Rhesus grouping of the patient should be employed, otherwise a Rhesus-negative mother may become sensitized by Rhesus-positive blood, with danger of erythroblastosis in subsequent pregnancies.

Anaesthetics

A pregnant woman does not tolerate spinal anaesthesia well and it is therefore wise to avoid this agent. Chloroform, which is particularly liable to cause liver damage, should also be avoided.

2. SURGICAL COMPLICATIONS OF PREGNANCY PECULIAR *TO THE GENITAL TRACT*

These complications are naturally the concern of the obstetrician, except when they simulate non-obstetric emergencies, and as such may be referred to the general surgeon.

(1) Concealed accidental antepartum haemorrhage

Couvelaire's uterus

In severe concealed accidental haemorrhage, retroplacental bleeding is associated with interstitial haemorrhage in the myometrium, and sometimes haemorrhage under the peritoneum covering the uterus and broad ligament. The myometrium, being atonic, is unable to control the bleeding, and the resulting condition is known as Couvelaire's uterus (Plate I).

(*a*) *Clinical picture*

Progression

The clinical picture is one of profound shock, with a small rapid pulse, cold clammy skin and an ashen-grey pallor. The blood-pressure is low, though this may be modified by the presence of hypertensive toxaemia. The urine may contain albumin, and if there is severe renal damage the output of urine is diminished or even suppressed. On abdominal examination the uterus is ligneous. Foetal movements and parts cannot be defined, and the foetal heart is inaudible. If the haemorrhage is progressive such a uterus can be observed by serial measurement to be enlarging. The danger of this condition is that it is progressive. The myometrium is incapable of contraction, so that even when the uterus has been emptied the only method of haemostasis lies in hysterectomy, which is a formidable proceeding in the presence of shock.

(*b*) *Treatment*

Hysterectomy

Treatment is therefore primarily to allay the shock by blood transfusion, and when it is judged that the optimum moment has arrived to open the abdomen, empty the uterus and if it does not contract, perform hysterectomy. This condition is mentioned because, if not borne in mind, the shock and abdominal pain may mislead the unwary into diagnosing some other abdominal catastrophe, and opening the abdomen unprepared to deal with the actual trouble.

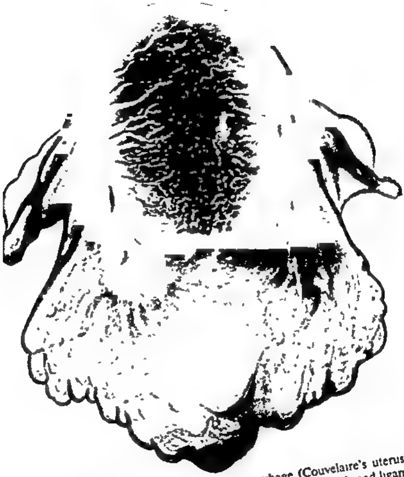
(2) Rupture of the pregnant uterus

Another obstetric catastrophe of interest to the general surgeon is rupture of the uterus during pregnancy. Rupture due to obstructed labour is in the province of pure obstetrics, and is therefore dismissed.

Rupture of the uterus during pregnancy (Fig. 47) usually follows a previous classical Caesarean section and is to be suspected particularly if there is a [illegible] puerperal sepsis. Sepsis in the uterine wound gives [illegible]

Diagnosis

[illegible] the patient that she suddenly felt something give way in the [illegible] some ruptures are clinically silent. Part or the whole of the uterine contents may herniate through the uterine hiatus and head or limbs may become readily



Concealed accidental antepartum haemorrhage (Couvelaire's uterus) Note subperitoneal haemorrhages in pouch of Douglas and broad ligaments.

PLATE I

palpable on abdominal examination. Not all these cases are associated with signs of peritoneal irritation, such as vomiting, shock and acute local tenderness, and in the more misleading of them, the process is an unobtrusive one. There may be no alarming haemorrhage from the uterine rupture, but there

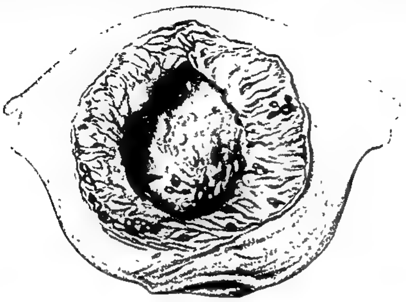


FIG 47—Rupture of the uterus through an old Caesarean section scar (classical operation).

will always be some local tenderness in the region of the uterus, and the pulse rate, if not already elevated, will soon rise, with deterioration of the clinical condition of the patient. Unless laparotomy is performed forthwith the foetus *Treatment* will be dead; it should be removed through the rupture which may need to be enlarged. The placenta must be expressed, and the uterus either removed or sutured after excision of the wound. If possible, the latter procedure is the more desirable, especially in a young and childless woman. If treatment has been prompt the uterine contents will be clean, and conservative surgery can safely be undertaken.

(3) Extra-uterine gestation

Cases of extra-uterine gestation are more often encountered by general surgeons than by gynaecologists. Some lives are lost because of tardy diagnosis and consequent delay in surgical treatment. It is therefore important to stress the following diagnostic points.

(*a*) *Menstrual irregularity*

Any menstrual irregularity during the childbearing period of a woman's life suggests the possibility of pregnancy, and most patients with extra-uterine gestation are found to have missed at least one period before the onset of bleeding and pain. The absence of amenorrhoea does not, however, exclude extra-uterine pregnancy. The amount and character of the bleeding does not differ significantly from that of a normal period, nor is there any reason why it should do so, since it is due to the necrosis of the decidua caused by the death of the trophoblast. If the trophoblast is alive there will be no bleeding.

(b) *Other diagnostic signs of pregnancy*

The other symptoms and signs of pregnancy are unlikely to be of great assistance in the diagnosis at the early date when an extra-uterine gestation declares itself.

(c) *Character of pain*

The character of the pain varies with the situation of the pregnancy. One situated in the interstitial part of the tube declares itself later than one in the isthmus. The pain can be divided into three successive phases. (i) The pain of tubal distension due to the presence of the ovum, which is of a dull aching character felt in the lower abdomen. (ii) The pain of tubal colic due to the attempted expulsion of the gestation sac and blood clot. (iii) The pain of peritoneal irritation due to free blood irritating the peritoneum. This peritoneal irritation may give rise to vomiting, shock, acute local tenderness and lower quadrant rigidity. Severe internal haemorrhage causes pallor, air hunger and rising pulse rate. Sudden haemorrhages cause syncope. If the bleeding reaches the diaphragm shoulder pain occurs.

Three phases of pain

(d) *Physical signs*

Vaginal haemorrhage is usually coincidental with the pain of tubal distension or colic. The blood is dark, fluid and moderate in amount. Bright blood that clots suggests the more violent haemorrhage of an intra-uterine abortion.

The distended tube may be palpable on pelvic examination. Sometimes the characteristic tender fullness may be felt in the fornices, due to blood in the pouch of Douglas, which may develop later into a haematocele. The signs of free fluid in the abdomen are obtained only with a large internal haemorrhage. The vaginal examination must be made with great gentleness to avoid the risk of increasing the blood loss.

(e) *Treatment*

The treatment of extra-uterine gestation, once diagnosed, is laparotomy supported by blood transfusion. If the surgeon considers that his patient is

Transfusion

from the patient's pelvis and flanks, but time should not be wasted in futile attempts at complete peritoneal toilet. Once the bleeding point is controlled the transfusion can be accelerated, if necessary using two veins and two bottles.

Technique of operation.—Speed is the essential of this operation and a generous sub-umbilical midline incision is quickest and best. On opening the peritoneum the offending appendage must be compressed between the surgeon's fingers. Adhesions, recent or old, may have to be freed to perform this manoeuvre, and when sufficient of the effused blood has been removed the tube is clamped and excised at leisure. It is probably false economy for the future to perform the conservative operation of salpingostomy in these cases since there is a risk of subsequent extra-uterine gestation due to the original cause.

dent al tubal on

It is finally emphasized that the other tube should always be inspected since there are many cases on record of bilateral extra-uterine gestation.

Late or secondary extra-uterine gestation will not be discussed, since this is a purely obstetric problem.

(4) Fibromyomas complicating pregnancy

Although myomas are associated with sterility this rule is not invariable; if, however, conception occurs, abortion frequently results. The situation of the myoma is largely the determining factor. A submucous myoma will certainly give rise to sterility or early abortion, whereas a subserous myoma is least likely to interfere with the pregnancy, though it is prone to undergo degeneration because of its inadequate blood supply, and if it is pedunculated torsion is likely to result. During pregnancy myomas are liable to become enlarged, softened and degenerate; during the puerperium red degeneration or necrobiosis is often seen. If a myoma is situated in the lower uterine segment or the cervix, it becomes an insuperable obstruction to vaginal delivery.

Sterility or abortion

Subperitoneal fibromas

Degeneration

Obstruction

The general surgeon is most likely to encounter a myoma which has degenerated or twisted, because in either case there may be acute pain, local tenderness and constitutional disturbances such as vomiting, fever, raised pulse rate and leucocytosis. The existence of pregnancy may be overlooked because it is not sought for or because it is deliberately concealed. The general surgeon may have been called in by a colleague to operate because the diagnosis is thought to be extra-genital.

(a) *Indications for laparotomy*

The indications for laparotomy in the case of myomas complicating pregnancy are few, and it should be stressed that conservative treatment gives good results in almost all cases. Such treatment consists of absolute rest in bed with careful observation of the pulse and temperature, attention to diet and bowels, and the exhibition of sedative drugs such as morphine in the first place, followed by phenobarbitone and bromide. The symptoms in most cases will subside under this treatment and the pregnancy will proceed to term.

(i) *Failure of palliative treatment.*—Laparotomy is reserved for those cases which do not resolve, or which deteriorate under palliative treatment. The symptoms and signs of such deterioration are pulse and temperature rates which refuse to settle, persistent pain, and vomiting or distension.

(ii) *Retention of urine.*—Another indication for surgical treatment is retention of urine caused by incarceration of the myomas and the pregnancy in the pelvis. If retention of urine occurs, the bladder should be decompressed over a period of 24 hours by passing a catheter and attaching a Laurie's drip chamber and clip to it, whereby the rate of decompression can be accurately controlled. When the bladder has been emptied it may be possible to manipulate the myoma and the gravid uterus out of the pelvis, in which case the pregnancy can be allowed to continue without surgical intervention. If this is impossible, the abdomen should be opened and myomectomy performed, if possible, without emptying the uterus; rarely it may be necessary to empty the uterus. In some cases the surgeon will be forced unwillingly to perform a hysterectomy.

Slow decompression of bladder

(iii) *Torsion.*—If an accurate diagnosis of torsion can be made on the physical signs, it is better to perform a laparotomy and myomectomy in anticipation of further trouble. A myoma which has twisted very soon acquires adhesions to the neighbouring viscera which may result in intestinal

obstruction and have even been known to give rise to intrap haemorrhage from the tearing of omental veins.

Extra-uterine pregnancy

(iv) *Uncertainty of diagnosis.*—A fourth indication for laparoton certainty as to the diagnosis. One such differential diagnosis is extr gestation or angular pregnancy.

(*b*) *Difficulties of myomectomy*

It is always advisable to perform myomectomy in preference to hyste in these cases, but the operation of myomectomy may be technically for several reasons.

Bleeding

Bleeding from the pregnant uterus is always considerable.

Situation of myomas

The situation of the myoma or the myomas may be such that it is n to empty the uterus by hysterotomy before they can be comforta cleated. This particularly applies to cervical or low-lying poster fibroids.

Number of myomas

There may be so many fibroids in the uterus that conservation is of or of no value, in which case hysterectomy is a better operation i saves the patient from another operation at a later date.

Abortion likely

Finally, it should be mentioned that however gently the operation mectomy is performed on the pregnant uterus, abortion is liable to re

Should the pregnancy remain undisturbed it is unnecessary to Caesarean section for fear of rupture of the myomectomy scar. Such heal soundly and, unless very recent, seldom rupture under the st delivery. Three months after the myomectomy the scar can be consider

(5) Ovarian tumours complicating pregnancy

The complications of ovarian tumours in pregnancy are torsion pedicle, haemorrhage into the cyst, suppuration and necrosis. The co

Torsion

Treatment

tion most likely to be met by the general surgeon is torsion, and the toms and signs are similar to those of torsion of a myoma. The trea provided the woman has another healthy ovary, is resection. Enuclea the ovarian cyst is rarely feasible because the ovary has already b infarcted.

Corpus luteum cysts

General surgeons should be conversant with the appearance of luteum cysts, which are frequently seen in early pregnancy. They rarely a size greater than twice the bulk of the normal ovary and need no trea since they regress if left alone. Many unnecessary oöphorectomies hav performed in the past for such simple corpus luteum cysts. The remova ovary containing the corpus luteum in the early months of pregnan been supposed to cause abortion, though this view is not universally ac (Shaw, 1948).

Technique of oophorectomy

The technique of oöphorectomy in pregnancy calls for no comment that the pedicle should be doubly ligated by a transfixion suture an stump covered by peritoneum to prevent the formation of adhesions.

(6) Peritonitis following abortion

This condition may well be encountered by the general surgeon becau patient is likely to give a false history and conceal the fact of pregnan she is the victim of a criminal abortionist she is likely to conceal the natu the operation that has been performed upon her. The case may therefo

presented to the surgeon as one of peritonitis of undiagnosed origin and it is only by expert and persevering cross-examination that the true state of affairs will be revealed. The history is therefore of great importance, and the nature of the instrumentation performed or the drugs taken should be noted. A general examination of the patient should reveal some signs of pregnancy, such as enlargement and venous engorgement of the breasts, or the presence of areola pigmentation and Montgomery's tubercles. It may be possible to express a little clear fluid from the breast, which is always a sign that a woman actually is or has been very recently pregnant.

(a) Symptoms and Signs

The symptoms and signs of this type of peritonitis do not differ from those of peritonitis due to other causes, such as appendicitis. The pulse is rapid, the temperature raised (although in the worst cases this is often subnormal); the patient is toxic, and the abdomen tender and distended. On rectal and pelvic examination there is great tenderness in the pelvis, and manipulation of the uterus may be extremely painful. Vomiting is usually present, and the bowels may be confined, although in pelvic peritonitis diarrhoea may be a feature. The urine is likely to be infected. A careful vaginal examination, using a speculum in a good light, may show bruising in the posterior fornix or even the small punctured tear of a misdirected instrument. The cervix may be torn; the bladder may be perforated. Bleeding from the uterus is not, as a rule, brisk, but a steady trickle of dark blood is almost always present.

(b) Peritonitis due to injection of chemicals

Many abortionists employ the injection of chemicals into the uterine cavity; soft soap solutions, carbolic, Dettol and permanganate have all been encountered. The woman herself may have inserted an enema nozzle into her external os, and in the determination to dislodge the ovum injected quantities of strong chemical solutions under great pressure. Such fluids undoubtedly find their way into the peritoneal cavity either by rupture of the uterus or by direct passage along the Fallopian tubes. Chemicals in the peritoneal cavity cause a type of peritonitis, the signs of which are baffling to a surgeon opening the abdomen. The bowel and pelvic viscera are uniformly inflamed and a little flaky exudate is present. There may be a perforation of the uterus, but this is not invariably present. Strong Lysol can cause gangrenous salpingitis. The bowel may have been perforated by the instrument causing the abortion and such a perforation should be looked for meticulously if the abdomen is opened.

Gangrenous salpingitis

(c) Treatment of peritonitis

The treatment of peritonitis following abortion is primarily conservative. The patient should be nursed under close observation, the pulse rate should be taken hourly and temperature readings frequently. Fluids should be given liberally, if necessary by intravenous drip. Large doses of penicillin and sulphonamides should be exhibited empirically. Nine cases out of ten will settle down under this treatment and at worst develop only a localized pelvic peritonitis, with salpingitis, and subsequent sterility. Even if the uterus has been perforated, this is not necessarily an indication for operation unless complicated by the prolapse of a piece of bowel or other abdominal contents through the rent.

Indications for laparotomy.—There are, however, occasional cases in which laparotomy is indicated. (a) The cases which fail to respond to conservative treatment, in which the pulse does not settle but rises, and the general condition of the patient deteriorates. (b) Cases in which there is suspected damage to the bladder or bowel. (c) Cases in which there are signs of intraperitoneal haemorrhage due possibly to a ruptured uterine artery. (d) Cases of severe uterine damage with rupture and laceration of the myometrium.

Pelvic abscess

With good fortune most cases of peritonitis following abortion will localize in the pelvis and at worst form a pelvic abscess. This can be drained at the optimum time through the posterior fornix by posterior colpotomy.

(*d*) *Treatment of perforations*

Bladder

Rectum

Small bowel

Drainage

The treatment of perforation of the bladder is excision and suture of the rent with continuous suction drainage of the bladder. Perforation of the rectum is probably best treated by colostomy and drainage. Perforation of the small bowel is treated by simple oversewing, and resection is unlikely ever to be indicated. There can be no general rules about drainage, but if it is to be employed it must be done thoroughly by suprapubic stab, and also by making an opening in the posterior fornix and putting a piece of corrugated drain out through the vagina.

3. GENERAL SURGICAL COMPLICATIONS OCCURRING IN PREGNANCY

(1) Gastro-intestinal tract

(*a*) *Physiology*

Low acid curve

Changes in gall-bladder function

Physiological changes during pregnancy cause profound alterations in gastro-intestinal function. There is a general hypotonia of the smooth muscle of the whole bowel, stomach and biliary tract, which accounts for many of the symptoms of pregnancy, such as dyspepsia and constipation. Fractional test meals performed on pregnant women show hypochlorhydria in most cases, and achlorhydria in up to 20 per cent of cases. Cholecystography reveals an increased emptying-time of the gall-bladder, a decreased concentration of the dye and a sluggish or inadequate response to a fatty meal. The emptying-time of the stomach is increased and the cardiac sphincter is hypotonic and relaxed. These facts account for the ready regurgitation of food and flatus, and the burning discomfort due to reflux of the stomach contents into the lower oesophagus. They also explain to some extent why the pregnant woman so rarely suffers from symptoms of peptic ulceration, and why pregnancy may be justly blamed as a causative factor in the production of gall-bladder disease.

(*b*) *Peptic ulceration and pregnancy*

Great rarity

Every surgeon appreciates the infrequency of peptic ulceration and of its complications of perforation and haemorrhage in pregnancy. In personal communications to the author Professor Grey Turner says he has ". . . never seen undue activity of a peptic ulcer during pregnancy", but is ". . . very familiar with the opposite state of affairs where ulcer symptoms disappear during cyesis"; Sir Gordon Gordon-Taylor ". . . cannot remember a perforated gastric or duodenal ulcer during pregnancy". Such testimony

from two surgeons of unrivalled experience in gastro-enterology demonstrates the extreme rarity of active peptic ulceration in pregnancy.

Literature of peptic ulcer complicating pregnancy

In a series of 10,000 women attending antenatal clinics, Avery Jones (1947a and b) found only one case of mild haematemesis and was unable to demonstrate any ulcer. In a further series of 2,000 women admitted with abortions only one had haematemesis and that was associated with acute renal failure. Mussey (1927), reporting 370 operations performed in pregnancy over 10 years, found only 2 cases of peptic ulceration. James (1948) has reported a perforated duodenal ulcer in a woman 36 weeks pregnant. This patient had a history of an ulcer preceding the conception. Sandweiss and his colleagues (1943), in a search of the literature, found 13 cases of ulcer complications in pregnancy and the puerperium confirmed by necropsy and 6 additional cases unconfirmed. Way (1945) has attempted to explain the rarity of ulcer complications in pregnancy by correlating the hypochlorhydria found in these patients with the secretion of anterior-pituitary-like hormones in the urine He concludes that the greater the secretion of the anterior-pituitary-like hormones, the more marked is the degree of hypochlorhydria. It may be assumed, therefore, that there is some endocrine explanation for the hypotonia and hypochlorhydria of the stomach during pregnancy, and that this is the most likely reason for the rarity of peptic ulcer activity.

(c) *Appendicitis in pregnancy*

Altered situation of appendix

Appendicitis in pregnancy is considered to be a relatively rare disease and this is roughly true. It does occur, however, and the clinical picture may be obscured by the upward movement of the appendix, which reaches its maximum height at the eighth month of pregnancy, when it lies about one inch above the level of the iliac crest. It is possible that this movement may disturb old adhesions formed in a previous attack. The common time for symptoms to occur is after the first three months of gestation. The symptoms and signs are the same as for appendicitis in the non-pregnant woman, except that the local tenderness over the appendix will be felt at a higher level. If the appendix is retro-caecal, the local tenderness will be felt high in the loin and therefore is readily confused with a right-sided pyelitis. If the appendix is pelvic in position, the symptoms will have a more gynaecological than surgical aspect.

Alteration in physical signs

(i) *Diagnosis and differential diagnosis.*—The laity expect every pregnant woman to be sick and to suffer from some abdominal pain, so that the sequence of abdominal pain and vomiting may be mistaken by the patient for part of the normal routine of pregnancy. Appendicitis occurring later in pregnancy may be mistaken for the pain of the onset of premature labour.

Pyelitis

It is pyelitis, however, which needs most care in differential diagnosis. In pyelitis the pain should be accurately localized to the post-renal angle, and the kidney, if palpable, is undoubtedly tender. It has been stressed that in pyelitis the temperature is high and the pulse slow, but every surgeon knows the misleading impression which temperature and pulse can provide in diagnosing acute appendicitis, so that it is perhaps wise not to emphasize this point. The most reliable sign is acute local tenderness over the area where the appendix would be expected to lie. Examination of the urine is important and the finding of pus and organisms in the urine is suspicious, though by no means conclusive. Pyelitis and appendicitis may well coexist. Further

differential diagnosis includes right extra-uterine gestation, twisted ovarian cyst, degenerate myoma, cholecystitis, and even right-sided pneumonia.

(ii) *Prognosis.*—The prognosis of acute appendicitis is more serious during pregnancy because of the greater risk of misdiagnosis and greater liability of spreading peritonitis. The higher position of the appendix is in itself more dangerous and there is always the threat of premature termination of the pregnancy with the possibility of puerperal sepsis superadded.

(iii) *Treatment.*—The treatment should always be appendicectomy.

(d) Intestinal obstruction and pregnancy

This condition presents difficulty in diagnosis because the symptoms of vomiting and colicky abdominal pain are common in pregnancy. The vomiting may be regarded as hyperemesis gravidarum and the colicky pain may be thought to be due to the onset of labour. In this way valuable time is lost in reaching the correct diagnosis.

(i) *Clinical history.*—The clinical history, however, is sometimes helpful if a previous abdominal operation has been performed. Especially significant are previous operations on the uterus and appendages, such as Caesarean section, myomectomy and ventro-suspension. The abdomen should be carefully inspected for scars and the history of previous surgical operations fully investigated. It must not be forgotten that unexpected lesions such as carcinoma of the colon can occur in the childbearing period of life and in 2 of Scott's 7 cases (1945) this was the cause of intestinal obstruction in pregnancy.

(ii) *Causes.*—The movement of the enlarging uterus may itself be the actual cause of the obstruction, a good example of which is when the small bowel has become adherent to the scar of a classical Caesarean section. During the process of involution in the puerperium the uterus may become retroverted into the pouch of Douglas, causing acute angulation of the adherent bowel. Bands and adhesions, by traction during pregnancy, can also cause obstruction. Some suspension operations in which the round ligaments are used as slings, may give rise to internal peritoneal foramina in three situations—between the anterior abdominal wall and the uterine body, and on either side of the round ligaments—and a coil of bowel may find its way into one of these foramina. As the pregnant uterus enlarges obstruction is liable to occur, especially if the bowel is adherent in such a position.

Adhesion between bowel and uterus

Artificial foramina after ventro-suspension

Appendicectomy scars, especially if there is the puckered mark of an old drainage tube signifying peritonitis and adhesion formation, are to be regarded with suspicion, and all hernial orifices must be carefully inspected.

Obstruction caused by adhesions

Obstruction due to volvulus has been described as associated with pregnancy. It may affect the pelvic colon, caecum or even the whole of the small bowel. Several of the reported cases have occurred during or soon after delivery, and it is thought that the torsion of the affected bowel is brought about by the rapid alteration of the abdominal contents following evacuation of the uterus. These cases are characterized by the sudden onset of severe, colicky, abdominal pain and rapidly increasing distension, localized at first, but later becoming general, together with persistent vomiting and shock. Persistent vomiting, during labour or soon after delivery, should arouse suspicion. In the recently delivered woman, the symptoms of volvulus may be

Volvulus

Characteristic features

wrongly ascribed to uterine rupture. The treatment is laparotomy and the earlier this is done the greater is the chance of avoiding resection.

(iii) *Treatment.*—Treatment of intestinal obstruction associated with pregnancy is laparotomy. As a rule the problem is a purely surgical one and the pregnancy can be neglected. Abortion or premature labour is likely to occur. If the presence of the foetus embarrasses the surgeon, the uterus must be emptied by hysterotomy. This procedure, if combined with resection of a gangrenous section of bowel, carries a formidable risk, but the surgeon has no option but to undertake it.

(*e*) *Cholecystitis and cholelithiasis*

Pregnancy seems to favour these two conditions because of the hypotonia of the muscle of the gall-bladder, increase of the cholesterin content of the blood, and the presence of hypochlorhydria or achlorhydria, which may encourage an ascending infection of the biliary tract from the gastro-intestinal tract. The multiparous woman is most likely to be affected and she may give a history of previous similar attacks of pain and tenderness in the right hypochondrium, with fever and possibly jaundice. Gastro-intestinal symptoms will again be masked, as in appendicitis, by those which she expects to be associated with pregnancy.

Physiological considerations in the aetiology

(i) *Diagnosis.*—Diagnosis is made on the history of previous attacks and on the symptoms and signs present. If cholecystography is performed it must be remembered that a poor concentration of the dye is normal in pregnancy and does not necessarily mean a diseased gall-bladder

(ii) *Indications for operation*—The indications for operation are no more urgent than in the non-pregnant woman but if necessitated in the early months of pregnancy, the operation presents no great technical difficulty. In the later months of pregnancy the presence of the uterus in the upper abdomen makes access to the gall-bladder difficult, and operation should be postponed if at all possible.

(iii) *Differential diagnosis.*—Jaundice with tenderness over the liver area is encountered in pregnancy, (a) in certain types of toxaemia with hepatic necrosis; (b) in acute yellow atrophy of the liver, and (c) in chloroform poisoning. The differential diagnosis of these conditions may present considerable difficulty.

(2) Cardiovascular system

(*a*) *Haemorrhoids*

External haemorrhoids are best treated by incision, evacuation of the clot, and excision of redundant skin under local anaesthesia. Internal piles are best treated conservatively until after delivery.

(*b*) *Varicose veins*

The frequency of varicose veins in pregnancy is attributed to the high concentration of circulating progesterone which causes a hypotonia of all smooth muscle throughout the body. There is also the increased vascularity of the pelvic organs which leads to an engorgement of all the pelvic tributaries. Injection treatment of varicose veins in pregnancy is possible, but should be avoided, since it is better to wait until the veins have involuted after delivery,

Treatment.—The best and safest treatment when the diagnosis is made is to put the patient to bed, pass a self-retaining catheter and attach this to a glass connexion and piece of tube and a Laurie's drip chamber. The bladder can then be slowly decompressed under direct vision by means of a screw on the rubber tube, over a period of 24–36 hours. If this technique is employed, almost every retroverted uterus will right itself without any further manipulation. Such rectification can be assisted by placing the patient in an exaggerated Sims's position.

(*d*) *Lone kidney in pregnancy*

Women who because of congenital defect or previous nephrectomy have only one kidney are usually safely delivered without accident. If the nephrectomy has been done for tuberculosis or carcinoma and soon after operation pregnancy occurs it should be terminated and future pregnancy avoided until the original surgical condition has become stationary. With these two exceptions the woman with the single kidney should be allowed to proceed with her pregnancy, provided that her renal function and the radiological appearances of her renal tract are normal. If, during pregnancy, albuminuria appears, or severe pyelitis supervenes, or the blood urea rises, then the pregnancy should be terminated forthwith.

(4) Diseases of the endocrine system

(*a*) *Thyrotoxicosis and pregnancy*

Physiological enlargement of thyroid

It is quite common to notice a generalized enlargement of the thyroid gland during pregnancy. This enlargement becomes noticeable about the fourth month, persists throughout the rest of the pregnancy and disappears in the first month of the puerperium. It is probably due to an increase in the thyrotropic pituitary hormone. Established thyrotoxicosis is rarely complicated by pregnancy, in that the condition tends to cause sterility. The incidence of pregnancy complicating thyrotoxicosis in the Mayo Clinic was under 1 per cent. Should pregnancy occur in a thyrotoxic patient there is an increased liability to abortion, premature labour and intra-uterine death of the foetus.

Myocarditis

The effect of the thyrotoxicosis on the pregnancy is chiefly seen in the incidence of heart failure due to a myocarditis. The diagnosis of the condition will present no difficulty to the surgeon, provided he does not ascribe to the pregnancy symptoms and signs which should more properly be credited to the thyrotoxicosis. The basal metabolic rate is raised by 25 per cent in the later months of normal pregnancy, so that corrections must be made for this physiological rise.

Treatment.—Treatment in a mild case is complete rest in bed and the administration of sedative drugs; *this may be sufficient to control* and alleviate the [illegible] that a safe spontaneous labour can be expected. Severe cases [illegible] th a physician who will decide upon the [illegible] *necessary to regard the pregnancy* as of [illegible]

dangerous as it is generally reputed to be.

(*b*) *Non-toxic goitre*

Enlargement during pregnancy may cause serious pressure symptoms; retrosternal goitres are particularly hazardous. If pressure symptoms develop, thyroidectomy is just as much indicated in the pregnant woman as in the non-pregnant woman, and it is not necessary to terminate the pregnancy to do this. A few cases will abort after operation. The great danger of obstructive goitres is that pressure symptoms may develop during the extreme expulsive effort made by the mother in the second stage of labour. The obstetrician will naturally reduce such expulsive efforts to a minimum.

(5) Abdominal parietes

(*a*) *Traumatic injuries*

Severe violence caused by automobile accidents, falls, blows, perforating wounds and the result of enemy action involving the pregnant uterus have all been reported (Gordon-Taylor, 1945). Such injuries urgently demand laparotomy, during the course of which a routine inspection of the viscera may reveal a rupture or wound in the uterus, with subperitoneal bruising. If the wound is not too extensive the uterus should be emptied by hysterotomy and the wound excised and sutured without drainage. If the uterus is extensively damaged it is better to perform subtotal hysterectomy, with careful peritonization of the pedicles and the cervical stump.

(*b*) *Herniae*

Herniae of all varieties are fairly frequently seen in pregnancy. The growing uterus, however, acts as an efficient obturator to the hernial orifices, and unless the bowel is adherent to the sac, tends to push the contents of the sac away out of danger. Incisional hernia, especially after Caesarean section, is not uncommon. Should treatment be necessary it should be undertaken immediately; the pregnancy need not be interfered with.

(6) Ear, nose and throat surgery, and teeth

Sometimes a severe septic focus in the teeth, tonsils or sinuses is found on routine examination. Such a focus is a real danger in the puerperium and should be eradicated early in pregnancy. Dental surgery can be safely carried out under local or general anaesthesia and is least likely to upset the pregnancy after the fourth month. The same applies to ear, nose and throat surgery. It is better to risk an abortion than the entrance of a pathogen into the genital tract.

(7) Malignant disease in pregnancy

There is no doubt that pregnancy accelerates the growth of certain carcinomas, notably breast carcinoma. In this disease there should be no hesitation in terminating pregnancy and forbidding it in the future until such time has elapsed as to render recurrence unlikely. In a young woman, 5 years is a reasonable period, though this time might be shortened for a woman whose reproductive life was limited. In the present state of our knowledge it is wise to regard pregnancy as having an adverse influence on any recently treated carcinoma anywhere in the body. Such patients should avoid pregnancy until their disease is reasonably quiescent and if pregnancy supervenes its termination is indicated.

REFERENCES

Dodds, Gladys H. (1931). *J. Obstet. Gynaec. Brit. Emp.*, **38**, 773.
Gordon-Taylor, G. (1945) *Brit. J. Surg.*, 33, 230.
James, D. W. (1948). *Brit. med. J.*, 2, 74.
Jones, F. Avery (1947a). *Brit. med. J.*, 2, 441.
— (1947b). *Ibid.*, 2, 477.
Mussey, R. D. (1927). *Proc. Mayo Clin.*, 2, 156.
Sandweiss, D. J , Podolsky, H. M., Saltzstein, H. C., and Farbman, A A (1943). *Amer. J. Obstet. Gynec* , 45, 131.
Scott, W. A. (1945) *Amer. J. Obstet. Gynec.*, 49, 494.
Shaw, W. (1948). Personal communication.
Turner, G. Grey (1937). *Lancet*, 1, 802.
Way, S. (1945). *Brit. med. J.*, 2, 182.

[References to other titles are given under Pregnancy—Surgical Intervention During in the Index Volume.]

PROSTATE

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1. INFLAMMATION

(1) Prostatitis

(a) Gonococcal and non-specific

278.] Acute or chronic inflammation may occur in the prostate. It is usually the result of gonococcal urethritis spreading from the posterior urethra, but it may follow a non-specific urethritis. *Prostatic abscess*

Acute prostatitis, from whatever cause, may lead to prostatic abscess; this may involve a small sub-urethral area only or the whole parenchyma of the gland. After the abscess has been opened or has discharged it is likely that chronic inflammation will remain for a long period.

(b) Tuberculous

Tuberculous infection of the prostate is associated with the same disease in the seminal vesicles, and sometimes in the upper urinary tract. It is a blood-borne infection from a primary focus elsewhere in the body. In a young man caseation occurs, giving rise to a purulent urethral discharge in which the tubercle bacillus can be found. In an older man the gland hardens and may closely simulate a carcinoma. Either type may go on to calcification (Fig. 49).

FIG 49.—Calcified tuberculous prostate and seminal vesicles.

FIG. 50.—Calculous prostatitis

(c) Calculous prostatitis

Prostatic calculi occur either as the numerous small stones sometimes associated with benign hypertrophy, or as the larger ones found in the inflammatory condition of calculous prostatitis which is a non-malignant type of prostatic abnormality which may produce obstructive symptoms. Here the histology shows chronic inflammation in an atrophic gland, and the changes of benign hypertrophy are absent. The whole gland is small and the ducts and acini contain pus. The calculi are probably secondary to infection and may attain a considerable size (Fig. 50). They are sometimes extruded into the urethra and may pass into the bladder to form the nuclei of vesical calculi.

The smaller stones found in many cases of benign hypertrophy lie behind the lateral lobes, between them and the compressed posterior lobe. They form in the longer ducts of the posterior lobe, possibly as a result of their compression by the enlarging lateral lobes, and hundreds of them are often found in this situation during the enucleation of an adenomatous prostate.

(2) Clinical features of prostatitis

(a) Symptoms

Acute prostatitis Acute prostatitis causes pain in the perineum and penis with strangury, painful erections, and pain on defaecation. A high temperature and rigors, with considerable increase in local pain, indicate the formation of a prostatic abscess, and the increasing size of the gland may bring on acute retention.

Chronic prostatitis Chronic prostatitis is characterized by a dull heavy pain in the perineum and groins, with frequency and pain on micturition. There is morning gleet and threads are present in the urine; a mucous discharge from the penis on defaecation, especially if the stools are hard, is almost pathognomonic.

Tuberculosis The symptoms of tuberculosis of the prostate are increased frequency of micturition with pain in the penis and in the perineum. Slight haematuria is sometimes present, and obstructive symptoms may occur in certain cases. Tubercle bacilli can be found in the urine or in any discharge.

Calculi The multiple small stones sometimes associated with benign hypertrophy give rise to no special symptoms, but a gland which is the seat of calculous prostatitis gives the symptoms of chronic inflammation rather than those of simple enlargement. Occasionally a larger stone is extruded into the urethra, producing partial or complete obstruction.

(b) Signs

In chronic prostatitis the prostate feels full and boggy and is moderately tender. *Prostatic abscess* In acute prostatitis the tenderness is greater, and in prostatic abscess there is a tense swelling which is so tender that a satisfactory examination may be impossible without an anaesthetic.

Tuberculous prostatitis The tuberculous gland presents areas of induration and of softening. It is generally tender and the seminal vesicles are palpably enlarged.

(3) Prognosis

Prostatitis, whilst not an immediate danger to life, is a cause of chronic sepsis and may be responsible for later upper urinary tract infection and stone formation.

Tuberculous prostatitis is associated sooner or later with tuberculous disease of the bladder and kidney; it may become arrested under suitable conditions and heal by calcification.

(4) Treatment

In acute prostatitis, when increasing tenderness, swelling and leucocytosis indicate the formation of an abscess, the cautious passage of a bougie may determine rupture of the abscess into the urethra; drainage by this method is often incomplete and it is better to open the abscess from the perineum in order to prevent its discharge into the rectum. Drainage of a chronic abscess into the urethra may be accomplished by the endothermy knife passed through a suitable posterior urethroscope. *Drainage*

Prostatic massage and rectal diathermy are beneficial in chronic prostatitis. Injections of tuberculin combined with a proper anti-tuberculous régime may help in tuberculous prostatitis. Preliminary trials with streptomycin in this disease have proved disappointing. *Tuberculin*

2. BENIGN HYPERTROPHY

(1) Aetiology

The only constant factor in benign hypertrophy is advancing age; in Great Britain the condition is rarely found before the age of 50 years and the maximum incidence is in the seventh decade. The condition is less common in Eastern races, but occurs at an earlier age. There is no evidence that its incidence is affected by particular habits, sexual excess or abstinence, or previous disease, except in the case of the fibrous prostate and calculous prostatitis in which previous urethritis and prostatitis have often existed. The enlargement is due to hypertrophy of the glandular tissue giving the appearance of adenomas; it is probably a degenerative change brought about by hormonic influences at a time when the balance of production between androgens and oestrogens is disturbed. *Age* *Race* *Nature of enlargement*

(2) Surgical anatomy

The surgical anatomy of the enlarged prostate differs from that of the normal gland in several respects. Both have a sheath of fibrous tissue derived from the visceral layer of pelvic fascia, containing fat and veins; deep to this is the true fibromuscular capsule, but whereas in the normal gland this is a thin layer closely attached to the prostate with no distinct plane of cleavage, in enlargement it becomes thick and laminated and an adenomatous prostate can readily be shelled out of it. The pathological capsule protects the large veins of the prostatic plexus which lie in it. These veins have a more or less vertical direction but with oblique and transverse communicating branches They form part of the pudendal plexus which receives the deep dorsal vein of the penis, and veins from the bladder, seminal vesicles, vasa and the prostate itself. It is from this venous plexus that haemorrhage occurs if the capsule is divided. The arterial supply comes from prostatic branches of the inferior vesical arteries which enter the postero-lateral surface of the gland at its upper part. Each divides into branches which pass to the urethral and peripheral parts of the gland.

The division of the prostate into lobes is apparent when the gland is enlarged. The main bulk is formed by the two lateral lobes which are involved in 90 per cent of cases of benign hypertrophy, whilst the small anterior lobe is only enlarged in 1 per cent. The posterior lobe, which covers the back and most of the lateral surfaces of the gland, is rarely the seat of adenomatous formation;

it becomes compressed and forms part of the pathological capsule so that in the usual enucleation it is not removed with the gland (Fig. 51). The group of acini which open into the floor of the urethra above the verumontanum enlarge and form a pathological middle lobe in about 40 per cent of cases It usually springs from one or other side of the midline of the floor of the prostatic urethra and tends to become pedunculated as the lobe rises towards and into the bladder. There is no prostatic tissue in the floor of the urethra below the verumontanum and this structure should mark the lower limit of enucleation posteriorly.

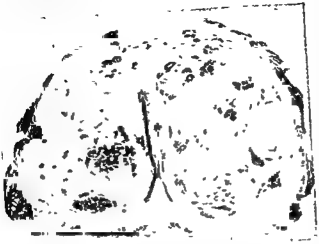

Fig. 51.—Section of prostate above the verumontanum; there are glandular nodules in the lateral lobes and the posterior lobe is compressed. (*Brit. J. Surg.*)

Weight

The weight of a normal adult prostate is about 20 grammes; in enlargement it may reach nearly 700 grammes (Thomson-Walker, 1920).

Prostatic urethra

The prostatic part of the urethra is normally about 1 inch in length with a slight forward concavity. As the prostate enlarges upwards as well as backwards [illegible] and the concavity is made more acute. The increase in distance of [illegible] re; [illegible] as this structure from the internal [illegible] and is sometimes [illegible] this distance can be measured on urethroscopy and is sometimes [illegible] a method of grading the degree of enlargement. The separation into grade 1, 2 or 3, however, is usually made arbitrarily by assessing the amount of backward projection and widening felt on rectal examination.

Grading

Curvature

The accentuated forward concavity of the prostatic urethra sometimes makes catheterization difficult, except with a fully curved catheter of the bicoudé type.

Fig. 52.—Tri-lobe enlargement with unequal lateral lobes.

(3) Pathology

In benign hypertrophy the pathological anatomy of enlargement shows considerable variations. The

lobes may be *enlarged individually or in combination.* The lateral lobes, which form the main mass of the prostate as felt on rectal examination, are usually both enlarged although often unequally; rarely the enlargement is unilateral (Fig. 52).

Posterior commissure

The posterior commissure may become thickened and form a bulge at the posterior lip of the internal meatus. Although this may occur without lateral lobe enlargement the commonest clinical entity is a combination of lateral lobe and posterior commissural hypertrophy which forms an inverted "U" of prostatic tissue at the internal meatus (Fig. 53).

Sub-cervical lobe

The sub-cervical lobe, which may form a pedunculated middle lobe projecting into the bladder, is usually but not always accompanied by lateral lobe hypertrophy (Fig. 54).

Sub-trigonal hypertrophy

Occasionally the gland burrows beneath the trigone forming a sub-trigonal hypertrophy distinct from the middle lobe types of posterior commissural or sub-cervical enlargement.

Anterior lobe

Anterior lobe enlargement is uncommon; it may account for persistent bleeding after resection of the lateral and middle lobes alone, but does not often produce obstruction.

FIG 53.—Common type of tri-lobe enlargement.

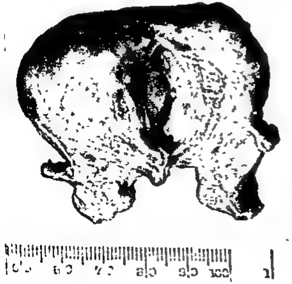

FIG. 54.—Large middle lobe with normal lateral lobes; the middle lobe has been split during enucleation.

Median bar

The median bar is a type of prostatic fibrosis which forms a sclerosed and contracted internal orifice; here the supramontine urethra is shortened instead of lengthened.

Histology

The histological picture of benign hypertrophy is one of dilated acini and epithelial proliferation. These changes in a group of acini produce a nodule in the gland which appears encapsulated owing to the compression of the surrounding stroma; each nodule forms an apparent adenoma and as these are usually multiple an enlarged prostate on section seems to consist of multiple adenomas. As age advances the acini tend to become cystic; their epithelium becomes flattened and desquamates and the walls between them break down. In the posterior lobe epithelial atrophy occurs earlier than in the rest of the gland. The histological picture is more suggestive of a degenerative change than of inflammation or neoplasm.

(4) Clinical picture

(a) Frequency

Nocturnal disturbance

In benign hypertrophy the onset is usually gradual, with increased frequency of micturition as the earliest symptom. Occasionally retention may be the first manifestation but in such cases a careful history often discloses previous nocturnal risings. The increased frequency is more noticeable by night than by day, the bladder losing its capacity of adaptation to increased content. It is probable too that there are early renal changes leading towards an equalization of the volume secreted during rest and activity. At first the nocturnal risings are confined to the early hours of the morning, but as the obstruction progresses they occur throughout the night and at about the same hour each night. Diurnal increase also occurs; it may take the form of repeated calls at short intervals during one period of the day only, with normal spacing at other times.

(b) Urgency

Urgency is often an early accompaniment of frequency and if the urge is not obeyed a little urine escapes. Interference with the bladder neck allows a little urine to enter the prostatic urethra, which is normally empty, causing a reflex desire to void. Both frequency and urgency are more marked in cold weather and are increased by change of posture.

(c) Alterations in the act of micturition

Diminished stream

Residual urine

Difficulty and delay in starting are more marked if the bladder has been allowed to overfill. The stream is less forcible and projectile power is lost; it may be intermittent and although the patient strains he is not able to increase its force to any extent. Such straining may determine the descent of a hernia into a preformed sac, or the occurrence of rectal prolapse. With failing bladder power there is terminal dribbling and the accumulation of residual urine; this reduces the effective capacity of the bladder and is an added cause of frequent micturition.

(d) Pain

Pain is usually absent unless there is cystitis; even a rough irregular vesical calculus does not necessarily cause pain as it lies in the retroprostatic pouch

protected from the contractions of a bladder which does not empty completely (Fig. 55). There may be a dull pain in the loins when the call to micturition is not obeyed; it is an indication of renal congestion.

(e) Haematuria

Haematuria occurs in about 11 per cent of cases and is more common in glandular enlargement than in the fibrous prostate, where it is seldom seen. It is a fortunate symptom, for whilst it rarely produces severe exsanguination it acts as a danger signal to the patient and makes him seek advice. It demands full investigation to exclude other causes of bleeding.

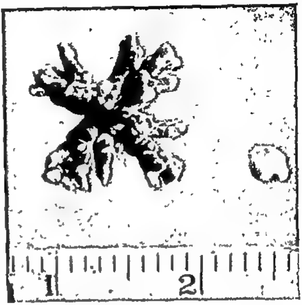

FIG 55.—Jack stone and smaller stone removed during prostatectomy, the stones did not cause pain.

(f) Priapism

In some cases the pelvic congestion produces frequent erections with an increase in sexual desire which may have embarrassing consequences.

(g) Acute retention

Acute retention may supervene on any cause of increased congestion and constipation or diarrhoea may precipitate the attack. It may also occur during some intercurrent disease involving confinement to bed, and must be anticipated particularly in the elderly man who contracts pneumonia or cardiac failure. *Intercurrent disease*

Symptoms.—Acute retention causes intense pain; the continuous urge to pass urine, with inability to expel more than a few bloody drops, the restless changes of posture, the sweating and apprehension form a picture of extreme agony. The relief when the bladder is emptied is dramatic.

(h) Chronic retention

In the absence of any attack of acute retention, or after such an attack has been relieved, the bladder may gradually become decompensated and retain progressively larger quantities of urine, ultimately becoming grossly distended. This condition of chronic retention is relatively painless, and the patient may be unaware of the large tumour filling his lower abdomen. Nevertheless, he is in a more dangerous state than the man with painful retention.

(i) Late symptoms

The late symptoms are due to dilatation of the bladder and of the kidneys. The urinary stream is still further reduced in force; during the day the muscular efforts of the abdominal wall produce a small dribble whilst at night the urine leaks out by overflow incontinence. If infection is added, as may happen *Overflow incontinence*

through injudicious catheterization, frequency is increased and pain appears on micturition.

Uraemia

Uraemic manifestations soon make their appearance; one of the earliest manifestations is a loss of the *sense of taste*, with dryness of the mouth and tongue and loss of appetite and weight. Nausea, vomiting and constipation occur later.

Mental changes

The mentality becomes sluggish, the patient is drowsy by day and sleepless by night and in due course becomes comatose. The rate of general deterioration is greatly accelerated by the presence of urinary infection. Typical uraemic convulsions are not common but may occur in the later stages.

(5) Prognosis

Although the condition is subject to remissions and relapses, depending to some extent on the season of the year as well as on the mode of life, its general tendency is to get worse, and when once the prostate has started to enlarge there is no known means of preventing its further increase.

Gradual deterioration

Even after acute retention from benign hypertrophy bladder function may recover for a year or more, but during this time there is a deterioration both locally and in general health, and in such a case one is wise to advise prostatectomy after the first attack. A successful prostatectomy in a relatively early case will add many years of comfortable life.

Effects of delay

If treatment is delayed unduly the bladder becomes atonic and there is progressive dilatation of the ureters and kidneys. Such a patient may be brought through a successful prostatectomy but the vesical atony often takes years to recover, and there is no regeneration of lost renal tissue. In consequence it is found that late cases do not make long survivors; they suffer from the effects of residual urine and renal impairment.

Mode of death

Death in an untreated case is usually from uraemia with superadded sepsis, but the immediate prognosis and the duration of life after operation depend as much on the cardiovascular condition as on any other single factor.

(6) Treatment

(*a*) *Expectant treatment*

As the effects are produced by mechanical obstruction it is rational to assume that they can be relieved only by surgical removal of the obstructing tissue. Nevertheless, there are certain medical measures which play a part in treatment. They comprise the precautions to be taken by a patient awaiting surgical treatment, namely the avoidance of cold, wet, over-fatigue, over-distension of the bladder, alcoholic or sexual excesses, constipation and diarrhoea. In the early stages of prostatic congestion these measures, combined with regularity of micturition, will do much to maintain normal function. The greatest danger of all expectant treatment is the masking of symptoms while progressive renal damage continues. When a patient with the early symptoms and signs of benign hypertrophy is advised that operation is not immediately necessary he must be kept under frequent observation.

Regulation of life

Risks of expectant treatment

The search continues for an effective method of treatment short of operative intervention but is so far unsuccessful save in the case of carcinoma of the prostate. Prostatic extracts produce no permanent improvement.

[illegible]ones

Hormones derived from the sex glands have been tried extensively. Testosterone improves bladder tone but has no effect on the size or histology of the

prostate. Oestrogens, which are so effective in carcinoma of the prostate, appear to have little effect in benign hypertrophy.

X-ray therapy X-ray treatment is of undoubted value in carcinoma and sarcoma of the prostate, and in controlling metastases, but has little apparent effect in benign hypertrophy.

Steinach operation The Steinach II operation of ligation of the vasa efferentia had a short-lived popularity but is not curative.

A catheter life is inevitably followed by infection of the bladder and usually of the kidneys. Squier (1913) showed that it reduced the expectation of life by nearly 50 per cent.

Permanent suprapubic drainage is a very poor substitute for surgical removal and few men will tolerate it.

(*b*) *Indications for operation*

The criteria on which the decision for or against operation is to be based are the local symptoms and signs, the renal function and the general condition. Twice-nightly frequency is not of itself an indication for operation, but when it reaches a degree that interferes with proper sleep it becomes so. The degree of delay or difficulty must be considered in conjunction with other factors, but increasing difficulty, with the threat of acute retention, is an indication for surgery. When acute retention has occurred, even if there is recovery after catheterization, operation should generally be advised. Repeated haematuria is a further indication. The persistence of enough residual urine to make the bladder palpable betokens the need for surgical intervention, as do recurrent cystitis and the presence of complications such as stone or diverticulum. All these criteria are made on the supposition that the prostate is enlarged per rectum; if this is not so, recourse must be had to cystoscopy and excretion urography in reaching a decision.

Renal function It is valuable to have an estimation of the blood urea or some other simple test of renal function at the onset, renal deterioration may be a deciding factor.

General condition Operation should be advised if a patient with these symptoms and signs is in good general condition, or if a general deterioration is due to the prostatic obstruction; if there is some other cause suitable measures for improvement should be taken before the decision is reached. Each case must be considered on its merits and there can be no hard and fast rule; *Associated conditions* assessment is difficult in a patient who seeks advice for some other condition such as a hernia, and who is found on routine examination to have an enlarged prostate.

(*c*) *Preliminary drainage*

The surgical methods of treatment available are per-urethral operations and open operations, and in either case the question of preliminary drainage may arise. There has been a recent advocacy of immediate prostatectomy for all cases without gross infection whatever the degree of renal damage (Wilson Hey, 1945; Walters, 1948); this is contrary to the experience of surgeons for nearly 50 years that a patient with chronic retention of urine submitted to a one-stage prostatectomy runs a grave risk of death from uraemia. *Importance of infection* The infective element is undoubtedly more important than that of renal impairment, but while the patient with chronic retention can sometimes be brought through a one-stage operation, provided that there is no gross infection, it is

this group of cases which provides the heaviest operative mortality; the risk can be greatly reduced by preliminary drainage.

(i) *Indications for drainage.*—The clear indications for preliminary drainage are serious urinary infection, chronic retention of urine, and renal insufficiency as indicated by a blood urea of more than 70 milligrams per 100 cubic centimetres. Other conditions which may indicate the need for preliminary drainage are serious diseases of the cardiovascular or nervous systems and intercurrent infections. These indications apply whether the operation is open or per-urethral.

(ii) *Methods of drainage.*—The methods of drainage are by urethral catheter, perineal urethrostomy, or suprapubic catheter.

A urethral catheter may be passed intermittently, or left indwelling for continuous drainage. It is often satisfactory for 2 or 3 days but for longer periods the danger of ascending infection is too great to make it a method of universal safety.

Perineal urethrostomy, which is the insertion of a catheter through a perineal opening in the bulbous urethra, has been claimed to have advantages over the urethral catheter (Sandrey, 1949). The anterior urethra is spared the risk of urethritis but there is still the danger of ascending lymphatic infection from the prostatic urethra and bladder neck.

Drawbacks of a low fistula

Suprapubic drainage through a large tube inserted low in the bladder, just above the symphysis, is unsatisfactory; the second-stage operation is through a field of fibrous tissue into a contracted bladder, with the danger of opening the peritoneum (Fig. 56). If drainage has to be long continued the site is unfortunate for the fitting of a belt, and the fistula frequently leaks. Closure after the prostate has been removed is often slow, with prolonged leakage. The method thus has serious drawbacks both for the patient and for the surgeon.

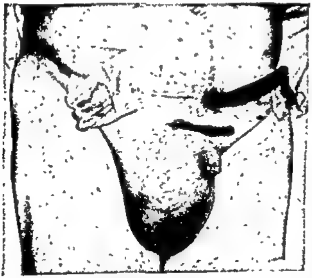

FIG. 56—Low suprapubic cystostomy, placed just above the symphysis pubis at the lower end of a long incision.

Size of suprapubic tube

A small catheter is equally effective for drainage in all cases except when the urine is grossly thick; a No. 16 (F.) catheter is adequate, but if drainage has to be continued for a long period the tube can be replaced by a larger one. Of even greater importance than size is the site of insertion of the catheter. It should pass through the abdominal wall well above the symphysis, and should run obliquely downwards and backwards to enter the bladder high on its anterior surface.

Site of fistula

Suprapubic catheterization

The method of suprapubic catheterization devised for spinal injury cases is eminently satisfactory (Riches, 1943) If the bladder is distended and the

catheter is passed obliquely downwards and backwards there is little danger of injuring the peritoneum. The joint is watertight and the valvular opening closes readily when the obstruction has been relieved (Fig. 57). If the bladder is not fully distended a short high incision is made through the abdominal wall and the catheter is introduced into the bladder under vision. The field for

(a) (b)

FIG 57.—Suprapubic catheterization (a) the small catheter is inserted midway between the umbilicus and the symphysis; (b) the catheter is held in place by a skin stitch and a shield (*Brit. J. Surg.*)

the second-stage prostatectomy is left free from scar tissue, and there need be no hesitation in giving the patient the advantage of a two-stage operation in a borderline case.

Duration of drainage

The duration of drainage will depend on the degree of improvement in the general state, the renal function and the vesical infection; after suprapubic catheterization about 10 days is considered the optimum, but if more than a fortnight is necessary the tube must be changed.

(*d*) *Per-urethral operations*

The indications for per-urethral treatment as opposed to open operation are contentious. There are two such methods: (a) endoscopic resection by the McCarthy type of instrument with a diathermic cutting loop, and (b) punch prostatectomy, exemplified by the Gershom Thompson cold punch.

The former gives better immediate control of haemorrhage, but more tissue can generally be removed with the latter.

(i) *Risks.*—Per-urethral prostatectomy is not a minor operation, and in dealing with a prostate of moderate size (grade 2 or over) it may put a more severe strain on the patient than open prostatectomy, and involve greater blood loss both during and after operation. A small resection is of no use for a large prostate and the more nearly the operation approaches total prostatectomy the better will be the result.

(ii) *Indications for per-urethral operation.*—The indications for the operation should be based on the size and type of the prostate rather than on the

Type of prostate

condition of the patient; suitable cases comprise mainly the fibrous prostates, median bar obstructions and the malignant glands of the primary scirrhus group. Small glandular enlargements where the amount of tissue to be removed does not exceed 15–20 grammes can also be resected, but the size of gland to be tackled varies with the skill and experience of the operator. Amounts of 100 grammes or more have been removed, and if necessary multiple sessions can be employed.

Size

(iii) *Anaesthetic.*—The avoidance of an inhalation anaesthetic is a favourable factor, a low spinal anaesthetic combined with Pentothal Sodium being adequate.

(iv) *Difficulties.*—The chief difficulty is due to primary haemorrhage, but it can be reduced appreciably by preliminary infiltration with adrenaline. If a large vascular gland must be resected the difficulties and dangers can be overcome by preliminary suprapubic catheterization of the distended bladder; through and through irrigation can be maintained during operation to keep the field clear and the tube can be used subsequently for lavage until the cavity is clean and the patient is passing urine normally.

(v) *Contra-indications.*—Per-urethral operations should not be employed for large vascular glands unless the operator is specially skilled in the method.

Hypertension

A high blood-pressure, particularly a high pulse pressure, is conducive to excessive bleeding.

Infection

Gross urinary infection implies the need for previous suprapubic drainage.

Small urethra

A small urethra is an absolute contra-indication and the forcible introduction of the 28 Ch. sheath in such a case will lead to the worst type of intractable stricture. The instrument may, however, be introduced through a perineal urethrostomy.

3. CARCINOMA OF THE PROSTATE

(1) Pathology

Carcinoma of the prostate is found in about 20 per cent of the prostatic cases coming for treatment. It occurs in two forms. The primary scirrhus type starts in the posterior lobe where it infiltrates early and is readily recognized. The secondary type is a carcinomatous change in a gland already the seat of benign hypertrophy; it often starts in a centrally placed adenoma where it is detected with difficulty but is more amenable to surgical treatment and appears to pursue a more benign course. There is no histological distinction between these two clinical varieties of carcinoma; both are composed of spheroidal cells with varying degrees of tubule formation. As in other sites, there is some evidence that a higher degree of differentiation betokens a less malignant tumour.

Primary scirrhus type

Secondary type

Carcinoma of the prostate spreads by direct continuity, by lymphatics and by the blood stream.

(a) *Direct infiltration*

Spread by continuity produces the infiltration which can be felt on rectal examination; it causes the obliteration of the lateral sulci and the median vertical groove and is responsible for the firm extensions of growth palpable in an upward and outward direction from the upper border of the gland into the base of the bladder and seminal vesicles.

(*b*) *Lymphatic spread*

Lymphatic spread is first into the pelvic lymphatics; a firm infiltrating band can be found in some cases running obliquely across the floor of the pelvis towards the enlarged internal iliac glands, and in time all the lymphatic and cellular tissue of the pelvis is invaded. Involvement of the nerves of the lumbo-sacral plexus causes sciatic pain. Spread continues into the common iliac and aortic glands; retrograde invasion of the external iliac glands and sometimes of the inguinal glands can occur but is uncommon. Further upward extension into the mediastinal, cervical and axillary glands is not infrequent.

Abdominal glands

Remote glands

Lungs

FIG. 58—Pulmonary metastases from carcinoma of the prostate.

(*c*) *Haematogenous spread*

Spread by the blood stream accounts for the deposits found in viscera and bone. The lungs are the viscera most commonly affected and the growth appears as a diffuse infiltration giving rise to a general mottling on the skiagram (Fig. 58) The vessels most concerned in the vascular spread are the vertebral venous plexuses which form an extensive and elaborate system of communicating channels running from in front of the sacrum up to the base of the skull and permeating the vertebral bodies (Batson, 1940). This route accounts for the early osseous metastases found in the sacrum, pelvis and lumbar spine (Fig. 59). Other bones are unlikely to be affected if this area is not involved.

Vertebral venous plexuses

Pelvic bones

(*d*) *Frequency of metastases*

The frequency of metastases in the different systems found at necropsy is lymphatic 77 per cent, visceral 34 per cent and osseous 28 per cent (Muir, 1934). The bones most commonly involved are the vertebrae, pelvis, ribs, femora, clavicles and skull, and amongst viscera the lungs, liver and kidneys.

(2) Clinical picture

Carcinoma

The symptoms of prostatic carcinoma are similar to those of benign enlargement with the addition of pain due to extension of the growth. This is experienced as sciatica, lumbago, or pain on sitting; prostatic symptoms with sciatica often betoken malignant disease. Loss of weight and symptoms from specific secondary deposits follow. A small area of carcinoma may remain completely symptomless until it has passed beyond the bounds of complete removal.

FIG. 59.—Osteoblastic metastases in the pelvis and spine from carcinoma of th prostate.

(3) Prognosis

In untreated carcinoma, death occurs from multiple metastases comb with urinary obstruction. The prognosis has been greatly improved by th of oestrogens in treatment, and there are cases alive and well for 5 years upwards. The adenocarcinoma pursues a less rapid course than the pri *scirrhus carcinoma*.

(4) Treatment

Oestrogens The treatment of carcinoma of the prostate has been greatly improve the discovery made by Huggins, Scott and Hodges (1941) that the adminis tion of oestrogens produces regression of the growth; the synthesis of ac oestrogens by Dodds and his colleagues (1938) made such treatment rea available.

Orchidectomy The alternative method of bilateral orchidectomy is not, as a rule, so succ ful, possibly because androgens are also formed in extratesticular sour The effect of oestrogens on carcinoma of the prostate is to produce a dimi tion in the size of the gland and a change in the histological picture in direction of increased fibrosis with diminution in number and size of tumour units (Fergusson and Pagel, 1945). There is often a gradual lessen of residual urine in a case of chronic retention without any surgical treatme and symptomatic improvement in other cases. Most cases of carcinoma of prostate, however, have some obstruction and this should be treated surgica at the same time as oestrogens are administered. In primary scirrhus carcino where the diagnosis is evident this is best done by endoscopic resecti

without attempting to remove the whole of the gland. In secondary adeno-carcinoma in an early stage or if the diagnosis is in doubt prostatectomy by the retropubic route is preferable; either method gives tissue for histological examination. In a bulky gland which is obviously malignant a preliminary suprapubic catheterization may be required to relieve urinary obstruction. If the gland is unexpectedly found to be malignant on exposure it can be treated by diathermy wedge resection or occasionally by retropubic radical prostatectomy.

Retropubic prostatectomy

Diathermy excision

Administration of oestrogens

Oestrogens are given by the mouth, the most effective preparation being stilboestrol. The initial dose of 1 milligram three times daily is increased by 1 milligram per dose each day up to 5 milligrams three times daily. This dose is continued for several months or until the improvement both symptomatically and in the value of the serum acid phosphatase indicates that it may be safely reduced. It is better to make a gradual reduction until a suitable maintenance dose, which may be 5 milligrams or less daily, is reached. This must be continued indefinitely or symptoms will recur and metastases appear.

Stilboestrol

Maintenance dose

In some patients stilboestrol may cause nausea and if this is severe hexoestrol or dienoestrol in the same dosage may be substituted. The experimental observation that dienoestrol is more powerful than stilboestrol is not borne out by clinical experience.

Nausea

FIG 60—Pigmentation of abdominal scar and enlargement of the breasts during treatment with stilboestrol. (*Proc. R Soc Med*)

Other side effects of oestrogen therapy are enlargement of the breasts, pigmentation of the areolae, of the mid-scrotal line and of any scars (Fig. 60), diminution in size of the penis and testes and loss of erection and of libido. The breasts may become painful and must not be rubbed by the braces Occasionally there is a rise of blood-pressure and sometimes oedema of the legs. These effects are lessened when the dose is reduced and must not be taken as an indication to stop treatment.

Breast changes

Pigmentation

Loss of libido

X-ray treatment may be combined with oestrogens.

4. SARCOMA OF THE PROSTATE

Sarcoma of the prostate is a rare disease found in male infants and occasionally in adults. In infants the tumour grows to a large size, usually producing retention and death from urinary obstruction with sepsis and uraemia before metastases have appeared.

5. THE FIBROUS PROSTATE

Inflammatory changes influence production of the fibrous prostate in which there is progressive replacement of the glandular nodules by fibrous tissue.

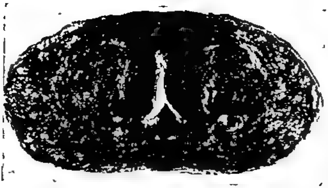

FIG. 61.—Fibrous prostate; there is replacement of the glandular nodules near the urethra by fibrous tissue. (*Brit J. Surg.*)

The fibrosis begins in the nodules close to the urethra *but may spread* throughout the gland (Fig. 61) When most of the glandular nodules are replaced by fibrous tissue the prostate becomes *dense and adherent to the capsule and is difficult to* enucleate. When the fibrosis involves the sub-cervical group of glands it causes stenosis of the *bladder neck or median bar, a condition which will* produce obstruction without prostatic enlargement.

Intermediate type

Between the purely glandular or adenomatous type and the fibrous prostate is an intermediate type in which fibrosis is more or less advanced.

6. SECONDARY PATHOLOGICAL CHANGES OF PROSTATIC OBSTRUCTION

Every surgeon must be familiar with the pathological changes in the urethra, bladder, ureters and kidneys which follow prostatic obstruction, whether it is benign or malignant. In the early stages of obstruction the ureter takes a right-angled or recurrent course towards the bladder; ultimately its orifice may become gaping, so allowing both pressure effects and infection to be *communicated directly to the kidney*. Dilatation of the ureters and renal pelves is relatively late and its degree depends on the duration of the obstruction (Kretschmer and Squire, 1948). The changes occur more rapidly in the presence of infection.

Hydro-ureter and hydronephrosis

The mechanism of obstruction

The cystoscopic and pathological picture of a middle lobe acting as a ball-valve fails to provide a complete explanation for the mechanism of prostatic obstruction, as enlargement of this lobe occurs in only a limited number of cases. Other factors are the disturbance of the circular muscle fibres at the *internal meatus by the enlarging gland, the elongation, angulation* and distortion of the prostatic urethra by the enlarged lateral lobes and, in the fibrous and malignant cases, the rigid tube of tissue which interferes with the reciprocal contraction of the detrusor and opening of the internal meatus by which the bladder is normally emptied.

The culminating *factor in acute retention in most cases is congestion*, brought on by excessive cold, wet, alcohol or sexual activity, or neglect of the natural call to empty the bladder; the detrusor becomes overstretched and, temporarily at least, atonic.

7. DIAGNOSIS

The importance of a thorough general examination cannot be overstressed;

vascular

Nervous system — Neurological examination will reveal the existence of tabes or other neurogenic causes of vesical dysfunction; carcinoma of the prostate may produce symptoms resembling peripheral neuritis.

Abdominal examination carried out after micturition should show whether the bladder is enlarged. Palpation of the renal areas and of the genitalia forms part of the routine examination.

Rectal examination — The diagnosis of prostatic enlargement depends largely on digital rectal examination. The dorsal position with the knees drawn up and separated is the most generally useful and allows bimanual palpation of the prostate if the bladder is empty. The modified lithotomy position for cystoscopy is also good from this point of view. Examination in more than one position is often necessary.

An attempt should be made to grade the prostate by size according to its width, vertical depth and the amount of backward projection; grades 1–3 cover most ordinary enlargements, with grade 4 retained for giant prostates.

Mobility — The features of benign hypertrophy are well known but it should be remembered that the whole gland is mobile and can be pushed up by a finger at its apex; the mucous membrane is movable over its surface. The benign prostate is not usually tender, and tenderness is more often found in a carcinomatous gland or in an infected one.

A scirrhus carcinoma is detected by its hardness, irregular surface, and the presence of infiltration which in time obliterates the lateral sulci. Extension upwards and outwards can often be felt. The gland becomes fixed, and the mucous membrane adherent and sometimes ulcerated.

Calculi — A central nodule of adenocarcinoma can only be detected or suspected by deep palpation. Such a firm nodule may be a calculus, but as prostatic stones are often multiple the added sign of crepitus may be felt on moving the finger; calculi and carcinoma sometimes coexist.

Fibrous prostate — The diagnosis between an adenomatous enlargement and a fibrous prostate [illegible]

carcinoma presents no difficulty, the detection of an early case is by no means easy

Examination under anaesthetic — It is sometimes advisable to make a rectal and bimanual examination under an anaesthetic, and this should certainly be done if an anaesthetic is being given for any other purpose.

Sarcoma — Sarcoma of the prostate may be suspected in an adult by the bulky nature of the indurated swelling. In an infant the prostate is enlarged and fleshy, but often the greater part of the enlargement is intra-vesical.

Bimanual examination — Whenever the bladder can be emptied and the patient is not too obese a bimanual examination should be attempted, the right forefinger being in the rectum and the left hand pressing deeply into the hypogastrium; an enlarged intra-vesical lobe can often be felt and it is easier to gauge the degree of enlargement in this way than in any other.

The act of micturition should be watched if possible; the poor force and loss of projectile power of the stream can then be appreciated.

The specific gravity of the specimen of urine should be recorded; a high (1 020) or low (1·002) value will indicate that there is no gross impairment of

nodules in the bladder. The main distinction in an earlier carcinoma is a lack of mobility of the lateral lobes which is appreciated when using an irrigating urethroscope. Inflow of fluid does not cause the lobes to fall apart to the same extent as in a benign case; this fixity is also seen in chronic prostatitis and to some degree in the fibrous prostate. *Fixity*

Increase in the antero-posterior diameter of the urethra with lateral lobe enlargement may expose the urethral floor down to the verumontanum to view with a right-angled telescope This appearance must not be confused with the wide and short funnel neck seen in nerve lesions. In prostatic enlargement the lateral lobes project into the urethra as smooth masses, and the normal hollow above the verumontanum may be occupied by the origin of a sub-cervical lobe.

Although cysto-urethroscopy gives so much information that it is rarely justifiably omitted, it must not be done indiscriminately. When the prostate is large and vascular it may cause haematuria or may precipitate acute retention. It is wiser in most cases to wait until the time of operation and to make cysto-urethroscopy the first part of the operative procedure, reserving preoperative cystoscopy for cases of real diagnostic doubt; in such an event a delay of 2 weeks before operating is advisable. *Time for cystoscopy*

FIG. 62.—Prostatic filling defect in the base of the bladder shown on excretion urography.

(2) Radiography

A skiagram of the pelvis should be obtained whenever carcinoma is suspected. It will show any pelvic osseous metastases, and determine the need for further skeletal x-rays (Fig. 59). It will also show prostatic calculi or calcification and serve as a diagnostic aid if the prostate is hard (Figs 49 and 50).

Excretion urography

Excretion urography gives additional information about the whole urinary tract, including the functional activity of the kidneys, and the presence and degree of dilatation of the renal pelves and ureters. The pelvic films show the size and configuration of the bladder, and the presence of diverticula or calculi; in some cases a smooth prostatic projection is shown as a filling defect in the bladder (Fig. 62). A film taken after micturition detects residual urine.

Filling defect

Despite the value of the information obtained, excretion urography is not necessary as a routine investigation of every enlarged prostate but should rather be reserved for the unusual case. It is complementary to cystoscopy and should precede it.

(3) *Acid phosphatase test*

When carcinoma is suspected the serum acid phosphatase should be estimated. A raised value (above 2·5 units) is suggestive of metastatic carcinoma—osseous, lymphatic or visceral

9. DIFFERENTIAL DIAGNOSIS

(1) Cystitis

Frequency and urgency of micturition can be caused by simple cystitis; when it fails to clear up or recurs quickly on proper treatment prostatic obstruction should be suspected in a man of the appropriate age.

(2) Obstructive lesions

The addition of difficulty, alteration in the stream and the presence of residual urine imply an obstructive element which may be of local or neurogenic origin. Obstructive lesions of local origin are stricture, phimosis and pin-hole meatus.

(a) Stricture

In stricture, whether inflammatory or traumatic, the patient is probably younger and it may be possible to obtain a relevant history. The stream is thin, its force may be increased by straining and there are usually threads in the urine. The passage of a bougie will complete the diagnosis. Rarely the two conditions, stricture and prostatic hypertrophy, coexist.

(b) Phimosis

Phimosis is apparent on examination; its occurrence in elderly men with increasing balanitis is often a sign of diabetes.

(c) Pin-hole meatus

Pin-hole meatus is most commonly associated with glandular hypospadias. Prostatic enlargement may also be present in conjunction with phimosis and pin-hole meatus.

(3) Neurogenic lesions

The commoner neurogenic lesions which may simulate or accompany prostatic obstruction are tabes dorsalis, disseminated sclerosis, transverse myelitis and spina bifida. They will all present other signs on examination of the central nervous system as will traumatic lesions of the spinal cord and cauda equina.

(a) Tabes dorsalis

In tabes the urinary symptoms may be the first to appear. The bladder is atonic, shows fine trabeculation and has an irregular outline, and there is a marked funnel-neck deformity. The patient is likely to be impotent whereas accompanying prostatic hypertrophy there is often increased sexual desire. Some cases described as "atonic bladder" may be due to early tabes. Some tabetics also have prostatic obstruction and their symptoms can be ameliorated by endoscopic resection or removal of the prostate.

Atonic bladder

(b) Disseminated sclerosis

Disseminated sclerosis is prone to produce precipitancy of micturition and incontinence rather than difficulty. The nystagmus, intention tremor, scanning speech and increased deep reflexes should help in diagnosis, but in an elderly man concomitant prostatic obstruction should receive attention.

(c) Myelitis

Infective myelitis occurs at a younger age and presents more marked signs of general and neurological disturbance.

(d) Spina bifida

Of the patients with spina bifida only those with the occult variety are likely to reach the age for prostatic obstruction, and these may be detected by x-ray examination and the cystoscopic signs of a neurogenic bladder.

(4) Other causes of haematuria

Neoplasms

Other lesions producing haematuria can be discovered on cystoscopy and radiography. A new growth of the bladder may produce obstruction if it is situated at the bladder neck and a new growth of the kidney can be recognized by cystoscopy during bleeding and by excretion or instrumental pyelography. A neoplasm other than of the prostate itself generally causes more profuse and total haematuria.

Vesical calculus

Stone in the bladder in an elderly man is so often a result of prostatic obstruction as to demand treatment of the prostate as well as of the stone to prevent recurrence.

Vesical varix

Rarer causes of haematuria such as varicose veins in the bladder will be seen with a cystoscope. In any doubtful case excretion and instrumental pyelography should not be omitted.

(5) Other causes of residual urine

Other conditions producing residual urine are vesical diverticula, atonic bladder and neurogenic lesions.

Diverticula

Diverticula are often only productive of symptoms when urinary obstruction supervenes. They may include complicating factors such as a new growth or a calculus. The latter, with its induration and the hypertrophic changes of chronic cystitis, has been mistaken for carcinoma of the prostate (Moder[illegible]

and the Law, 1948). A large diverticulum may cause an irregular outline to the distended bladder on abdominal palpation, but any grossly distended bladder is often asymmetrical.

The differential diagnosis of the individual types of prostatic obstruction has been considered with the signs of the disease.

10. OPERATIVE TECHNIQUE OF PROSTATECTOMY

(1) Pre-operative management

Procedure varies according to whether one is dealing with (1) the uncomplicated case, (2) the patient with acute retention, or (3) the patient with chronic retention.

(*a*) *The uncomplicated case*

Blood urea

(i) *Renal function tests.*—These tests are necessary; they should combine safety with convenience and accuracy. A raised blood urea will show renal insufficiency as distinct from renal impairment. There are many fallacies in the test but it is one of much practical value, and is both safe and convenient; the normal is 20–40 milligrams per 100 cubic centimetres. The blood should be taken when the patient is fasting. Lesser degrees of renal impairment can be shown by excretion tests.

Specific gravity

The range of specific gravity can be gauged by concentration or dilution. Fluid is withheld for 12 hours (overnight) and the specific gravity of the first two or three morning specimens is taken; it should reach 1 022. As a dilution test 2 pints of water are given by mouth within half an hour; the specific gravity of the urine within 4 hours should be as low as 1·002.

A fixed specific gravity of 1 010 after either fluid restriction or copious drinking represents the maximum impairment, and such cases are unsuitable for any but drainage operations.

Indigo-carmine test

The indigo-carmine test, whether done with or without a cystoscope, gives an immediate result without the delay of laboratory investigations. Four cubic centimetres of 0 4 per cent indigo-carmine injected intravenously should produce a blue coloration in the urine in from 4 to 7 minutes.

Urea clearance test

It has been shown (Riches and Robertson, 1935) that the urea clearance test, which combines both blood and urine estimations, gives the highest degree of accuracy, but it is doubtful whether such a complicated test is necessary except in selected cases.

Excretion urography

Excretion urography also serves as a test of renal function and has the added advantage of showing anatomical structure; it is contra-indicated in the presence of severe renal impairment and the blood urea should be estimated first in any doubtful case.

Other tests of renal function

There are many other tests of renal function (Riches, 1948) but whatever tests may be dictated by individual preference it is better to rely on the results of at least two, one of elimination and one of retention, and not lightly to discard any well-tried test which experience has shown to be reliable.

(ii) *General condition.*—The results of laboratory tests are of less importance than clinical findings. Loss of appetite and taste, dryness of the skin and tongue, thirst, nausea and headache all point to renal damage.

Excessive obesity increases operative risks, and it is often wise to institute a weight-reducing régime before operation.

The condition of the heart and vessels may preclude any but a minor operation, and in deciding upon treatment as well as in assessing prognosis a complete examination by a cardiologist is of the greatest value; he must be conversant with the amount of shock produced by a modern anaesthetic and operation. Whilst minor degrees of hypertension are no bar to operation, in a more severe form it may indicate the need for rest and for a two-stage operation. The blood-pressure tends to fall after drainage. Cardiac irregularities, particularly auricular fibrillation, require rest and digitalis and in congestive heart failure mercurial diuretics can often be used with advantage. An electrocardiogram should be taken in order to assess the state of the myocardium. *Cardio-vascular system*

The mental condition must also be considered; incipient uraemia produces sluggish reactions, and cerebral vascular disease may be a precursor of post-operative mental complications *Mental state*

(iii) *Time for investigations.*—Most of the foregoing investigations are best made before the patient's admission in order to reduce the pre-operative period of hospitalization. If the results are satisfactory admission 2 days before operation is adequate.

(*b*) *The patient with acute retention*

(i) *Catheterization for the relief of pain.*—Acute retention is painful and requires immediate relief, and the time-honoured use of the catheter is still correct provided that gentleness and strict asepsis are practised. A local anaesthetic (for example, Nupercaine, 1 : 1,000, 1 ounce) is desirable; a bicoudé gum-elastic catheter, size 16 (F.), is more likely to pass readily than a soft rubber instrument, and the metal fully-curved prostatic catheter is rarely necessary. The bladder can safely be emptied but arrangements should be made for immediate admission so that the dangerous practice of repeated catheterization can be avoided. A single catheterization is sometimes followed by a return of micturition which gives time for essential investigations and a decision on the need for a one-stage or two-stage operation. If micturition is not re-established and no assessment of renal function has been possible the safest practice is to put in a suprapubic catheter and wait until conditions are suitable for prostatectomy. Drainage may be the means of preventing serious renal infection. If the clinical state is satisfactory and the urine clear, immediate prostatectomy may be considered. Intermittent catheterization prolonged for more than about 2 days is usually followed by infection. The practice of leaving a tied-in catheter carries a greater danger of the same issue. If it is done a rubber Foley catheter with a 5 cubic centimetre balloon is the best instrument; a gum-elastic catheter provokes severe urethritis. The catheter is connected to a closed drainage system such as that of Dukes or a tidal drainage apparatus whereby intermittent lavage can be carried out. Whenever catheterization is practised a sulphonamide should be given by mouth (0 5 gramme, 6-hourly), and the fluid intake should be increased to 6 pints daily; the penis should be enveloped in an occlusive dressing soaked with a suitable antiseptic (for example flavine in paraffin). *Repeated catheterization to be avoided* *Infection* *Sulphonamides*

(ii) *Aspiration.*—As an alternative to catheterization the bladder may be emptied by suprapubic puncture with a serum needle inserted obliquely from a point well above the symphysis. Too frequent repetition of this manoeuvre may lead to extravasation.

(c) The patient with chronic retention

Absence of pain

This implies the more dangerous condition of a relatively painless retention; it may be accompanied by overflow incontinence if the bladder is very distended.

In such a case the bladder should not be emptied immediately; the condition has probably existed for some time and a further short delay is of little consequence. The patient should be admitted as soon as possible; blood is taken for urea estimation and suprapubic catheterization is carried out, with gradual decompression of the bladder over a Kidd's U-tube for a period of 12 hours. The subsequent investigations already detailed can then be carried out at leisure, with the patient ambulant until he is fit for prostatectomy.

Gradual decompression

Immediate prostatectomy.—In some clinics it is the practice in such cases to do an immediate prostatectomy provided that the urine is sterile. Despite many successes suppression of urine is still liable to follow the sudden emptying of a chronically overdistended bladder. Wilson Hey (1945), who is an advocate of immediate prostatectomy, had a total mortality of only 6 per cent, but the mortality rate was 16 1 per cent in cases in which the blood urea was between 80 and 200 milligrams per 100 cubic centimetres and 66 6 per cent when it was over 200. Some of these serious cases can be saved by a two-stage operation

(d) General measures

In all cases, whether preliminary drainage is required or not, the usual pre-operative care is needed. The bowels are best moved by an enema on the night before operation unless they have already been well open. Fluids are forced, up to 6 pints daily; pre-operative intravenous fluid is rarely indicated except in the uraemic case. It must always be given with restraint in a patient of prostatic age.

Fluids

Adequate sleep must be ensured by suitable sedatives, bearing in mind that continuous sleep for more than 3–4 hours is not desirable in most prostatic patients.

Infection

If the urine is infected the appropriate chemotherapeutic substance should be given. Sulphonamides, penicillin and streptomycin all have their uses, and it is desirable to start a routine course of a sulphonamide (0 5 gramme, 6-hourly) and penicillin 12 hours before operation. It is likely that streptomycin will largely replace or supplement the other two as supplies become available for prophylactic treatment.

Respiratory system

Breathing exercises should be commenced on the day of admission and continued throughout the pre-operative and post-operative periods.

Anaesthesia

In all prostatic operations it is essential to have the services of a highly skilled anaesthetist who is ready to modify his methods to suit the particular patient.

(2) Drainage operations

(a) Suprapubic cystotomy

The patient is put into a slight Trendelenburg position. The bladder is usually filled and should be washed out if there is infection.

(i) *Incision.*—The skin incision may be a vertical one, not more than 2 inches in length, with its centre at the mid-point between the umbilicus and symphysis. A short transverse incision at the same level gives adequate exposure and

prevents downward displacement of the catheter should the wound break down. The linea alba is divided vertically and the recti are separated. The peritoneum is pushed up by the finger and the bladder recognized by its muscular fibres and the vertically running veins on its surface. *Exposure of bladder*

(ii) *Introduction of catheter.*—The bladder is held by two fine bladder hooks and the selected catheter introduced. This may be a Malecot self-retaining

FIG. 63 —Morson's suprapubic trocar and cannula.

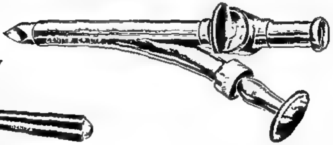

FIG. 64 —Kidd's suprapubic trocar and cannula. Withdrawal of the trocar by the side channel allows the catheter to be inserted through the central channel without leakage.

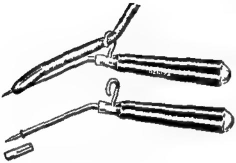

FIG 65.—Hamilton Bailey's suprapubic catheter introducer.

type stretched on an introducer. It is inserted through a Morson's or Kidd's suprapubic cannula after the trocar has been withdrawn (Figs. 63 and 64), or by Bailey's introducer (Fig. 65), and escape of bladder contents should be prevented. Alternatively the catheter introducer shown in Fig. 66 can be used. The catheter is pushed down nearly to the base of the bladder. A small rubber pre-vesical drain is inserted, the recti are closed by one or two catgut stitches and the wound is closed. The catheter is anchored by a loop stitch which does not perforate it. The bladder is emptied at once or decompressed slowly as circumstances dictate.

(iii) *Exploration.*—If it is necessary to explore the bladder, as for example to remove stones, a longer incision must be made. The wound in the bladder is closed from below with the catheter coming from its upper end and emerging through the skin wound well above the symphysis. An open suprapubic cystotomy will make the prostatectomy a little more difficult, but in no circumstances should a low fistula just above the symphysis be made.

(*b*) *Suprapubic catheterization*

This operation can be done with a local anaesthetic and is suitable for any patient, however ill, provided that the bladder is or can be distended, but not otherwise.

With the patient in sufficient Trendelenburg tilt to make the lower abdominal wall horizontal a skin weal is made opposite the highest point of bladder dullness, or the mid-point between the umbilicus and symphysis, whichever is the lower. The rectus sheath and bladder wall are infiltrated with anaesthetic, the *Site of puncture*

Absence of pain

(c) *The patient with chronic retention*

This implies the more dangerous condition of a relatively painless retention; it may be accompanied by overflow incontinence if the bladder is very distended.

Gradual decompression

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...tory

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...sia

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The patient is put into a slight Trendelenburg position. The bl... is usually filled and should be washed out if there is ...

(i) *Incision.*—The skin incision ... in length ...

A sho...

needle passing downwards and backwards. A small incision (¼ inch) is made in the skin and rectus sheath in the same direction. The catheter (size 16 (F.)) is placed on the introducer (Fig. 66) and its lower pointed end fixed by screwing up the small knife blade; it is then stretched and the upper end is fixed on the serrations and well lubricated (Fig. 67). The introducer with the

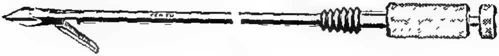


FIG. 66.—The Riches suprapubic catheter introducer.

FIG. 67.—The catheter fixed on the Riches introducer.

FIG. 68.—Suprapubic catheterization; the introducer makes an angle of 45 degrees with the abdominal wall.

catheter is passed through the incision in a downward and backward direction, making an angle of 45 degrees with the abdominal wall until it is felt to enter the bladder (Fig. 68); the knife blade is then unscrewed, the catheter head recoils, and the blade is closed again. The introducer is withdrawn,

FIG. 69.—The advancer for adjusting the position of the suprapubic catheter.

Advancement

Fixation

leaving the catheter *in situ*. The catheter is then pushed on with the advancer (Fig. 69) to the required depth, usually the 4 or 5 inch mark. It is held in place by an encircling stitch and a rubber shield is threaded over it and held

by ■ strapping corset. The opening is entirely leakproof and after decompression over a Kidd's U-tube the patient can be allowed up. If drainage is necessary for more than 2 weeks the catheter is changed by removing the old one and passing a St. Peter's Hospital catheter of the same or larger size along the track, retaining it by a shield and strapping. The new catheter must be inserted as soon as the old one is removed, as the small fistula closes very quickly (Fig 70).

Change of catheter

FIG 70 —Specimen after suprapubic catheterization; the long oblique track prevents leakage (*Proc. R. Soc. Med*)

(c) *Urethrostomy*

A rubber catheter is passed to its full extent into the bladder, its proximal end being grasped by a pair of long curved forceps (for example, peritoneum forceps). The forceps is then advanced as far as the bulb of the urethra and rotated so that its point projects into the perineum. An incision is made on to the forceps and the catheter, released from the forceps, is withdrawn, its length being adjusted so that it lies just within the bladder. Finally the catheter is stitched to the skin.

This method provides dependent drainage but the fistula may not always close readily when required.

(3) Per-urethral operations

The technique of these operations is not easy and can be learned only by a long apprenticeship.

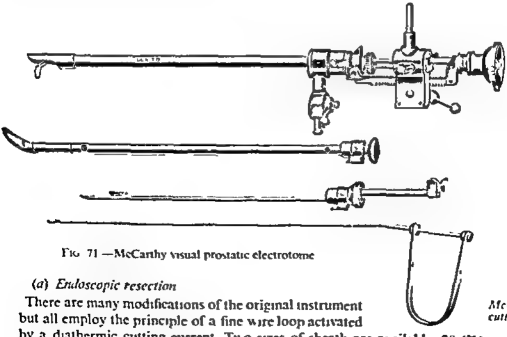


FIG 71 —McCarthy visual prostatic electrotome

(a) *Endoscopic resection*

McCarthy cutting loop

There are many modifications of the original instrument but all employ the principle of a fine wire loop activated by a diathermic cutting current. Two sizes of sheath are available, 28 (F.) and 26 (F.), the cutting loop in the latter is smaller (Fig. 71)

With the patient in position for cystoscopy metal bougies are passed up to the size of the sheath to be used. The instrument is introduced and the bladder neck and prostatic urethra are examined, careful note being made of the size and position of the verumontanum as this is the landmark below which no cutting is permissible. It is useful at this stage to inject, by means of a long needle, 0 25 cubic centimetre of adrenaline (1 : 1,000) in 10 cubic centimetres of Nupercaine (1 : 1,500) or other suitable vehicle (Fig. 72). The injections are made into the lobes to be resected, the solution being divided between

Haemostatic injection

FIG 72.—Prostatic needle for injection of adrenaline.

them. Cutting may commence at one lateral lobe, then at the other, the middle lobe being left as a convenient landmark until the end. The pieces fall back into the bladder whence they are subsequently sucked out by a Freyer's evacuator. When sufficient prostate has been resected bleeding points are coagulated by means of the ball electrode. The bladder is washed clear, 5 cubic centimetres of thrombin (topical) are injected into the prostatic cavity and the instrument is withdrawn. A Foley catheter (20 (F.)) is inserted, the balloon being inflated to about 15–20 cubic centimetres according to the

Haemostasis

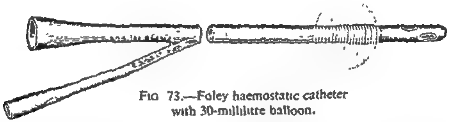


FIG 73.—Foley haemostatic catheter with 30-millilitre balloon.

amount removed; it is drawn into the prostatic cavity to exert pressure (Fig. 73). If haemostasis has been satisfactory a spigot is placed in the catheter for 1 hour and then free drainage allowed; occasional lavage with a Canny Ryall syringe is employed to keep the catheter clear of clots. If haemostasis is less

After-care

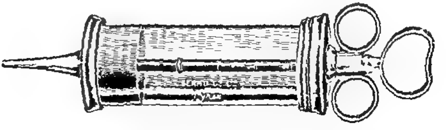


FIG. 74.—The Riches glass and metal bladder syringe.

satisfactory lavage must be started at [illegible] kept up at brief intervals for as long as is necessary. A [illegible] (Fig. 74) and sodium citrate (3·8 per cent) [illegible], to prevent clotting.

(b) Punch operations

The Thompson punch is a size 30 (F.) endoscopic sheath with a tubular knife fitting inside it and a fenestrum near the tip into which the prostate can be made to project (Fig. 75). Haemostasis is effected by a coagulating electrode. There is a single lens at the eyepiece, and no telescope. After dilatation

Fig. 75.—Gershom Thompson prostatic punch.

of the urethra the instrument is passed and the bladder washed out. Cutting proceeds by the successive removal of fragments projected into the fenestra. Any serious bleeding should be checked by coagulation as it appears. When resection is complete the fragments are evacuated as before and attention is given to haemostasis. Thrombin is instilled and a Foley catheter is inserted and similar post-operative treatment as for loop resection is carried out.

(c) Comparison of methods

It is possible to deal with larger prostates with the punch than with the loop, but haemorrhage is greater and the need for blood transfusion more frequent; post-operative sepsis and secondary haemorrhage are less.

Any inclination to overdistend the balloon of the Foley catheter should be resisted as it may be followed by temporary incontinence from stretching of the external sphincter. *Foley catheter*

In both punch operations and endoscopic resection the catheter can be removed in 2 days if there is no serious bleeding, and the patient is allowed up. It is advisable to re-examine the urethra after a week and to trim any projecting portions of prostate which can be a source of infection. *Re-examination*

(4) Open operations

(a) Suprapubic prostatectomy

The steps common to all operations for suprapubic removal of the prostate are the opening of the bladder, the enucleation of the gland, haemostasis and drainage.

(i) *Freyer's operation.*—In Freyer's operation the bladder is opened through a short vertical incision of 2½–3 inches. Enucleation is started by scoring through the mucous membrane behind the projecting part of the gland, originally with the ungloved forefinger of the right hand; the left forefinger is placed in the rectum to give support. Haemostasis is provided by hot irrigation or if necessary by packing, and drainage is by a large suprapubic tube retained for 3 or 4 days, and a small pre-vesical drain. Subsequently a Hamilton Irving box is worn until the wound is dry. *Incision*

(ii) *Thomson-Walker's "open" operation.*—In Thomson-Walker's [illegible]

[illegible]

[illegible]

[illegible] to give a view of the bladder neck. The shelf of mucous

Excision of shelf

membrane and muscle forming the apex of the trigone is cut away, the edge of the cavity is trimmed, bleeding points are picked up and stitches put in around the rim of the cavity. Drainage is by urethral catheter and suprapubic tube, the latter being smaller than that used by Freyer owing to the more efficient haemostasis. The tube is removed in about 4 days and the catheter in 7 days.

(iii) *Harris's operation.*—In the Harris operation the skin incision is usually transverse, the recti being separated vertically. The bladder is left empty before the operation starts.

Enucleation is started within the urethra, the forefinger passing down to the lowest point of each lateral lobe in turn and breaking through backwards along an oblique line which passes above the verumontanum before sweeping around the lateral lobes. In this way the mucous membrane of the urethral

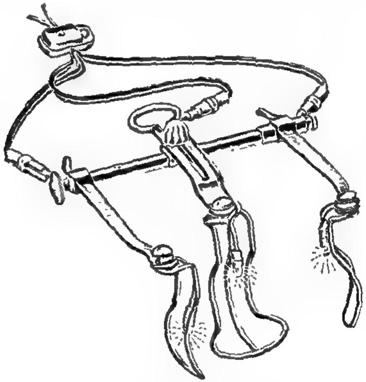


FIG. 76.—Morson's illuminated bladder retractor.

floor below the verumontanum is not removed. An illuminated retractor is inserted (Fig 76), tags in the cavity are removed, and the shelf of tissue forming the apex of the trigone is stitched down to the urethral floor. This is done by means of a boomerang needle which enters in the midline just behind the inter-ureteric bar and emerges in the floor of the urethra. Besides [illegible] floor this retri-

Retrigonization stitch

[illegible]

Transverse stitches

are picked up and secured by ligation. Two [illegible] stitches are then passed across the front of the prostatic cavity in order to approximate its walls, leaving room for the forefinger to pass into the new urethra behind. A thin-walled rubber catheter (size 20 (F.)) is passed along the urethra and anchored in position by a stitch which is brought from the tip

of the catheter through the abdominal wall and fastened by a button, glass rod or rubber tube (Fig. 79). The bladder is closed completely but a small pre-vesical drain is inserted for 48 hours. The catheter is removed in from 7 to 10 days.

(iv) *Wilson Hey operation.*—Apart from his advocacy of a one-stage operation for all cases, Wilson Hey stresses the vital importance of strict asepsis throughout. After the removal of the prostate the patient is tilted into the Trendelenburg position and the trigone is liberally excised up to the inter-ureteric bar and ureteric orifices. All tags in the cavity are removed and meticulous haemostasis is achieved by sealing all bleeding points with diathermy. A catheter is passed from the prostatic cavity outwards along the urethra to avoid introducing infection from without, and the bladder is closed completely. The catheter is removed on the second day or earlier.

Asepsis

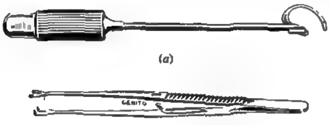
Trigonectomy

Haemostasis

Drainage

(*b*) *Retropubic prostatectomy*

Millin's operation.—In 1945 Millin introduced a route of approach to the prostate below the bladder. The bladder is left empty after the preliminary cystoscopy; the skin incision is vertical or transverse, the recti being separated vertically. The retropubic space is opened up with the forefinger; the bladder is pushed upwards and backwards and held in this position by a



(*a*)

(*b*)

FIG 77 —(*a*) Blunt boomerang needle; (*b*) ligature carrier.

retractor In front of the prostatic capsule is the fatty pelvic fascia containing large friable veins. These are underrun with a blunt boomerang needle and tied before being divided (Fig. 77). The fascia is then displaced laterally by packs inserted into the recess on each side of the prostate. The prostatic capsule is now displayed and is to be divided (Fig. 78 (a)) This may be done transversely, with a small long-handled scalpel as advised by Millin, or vertically in the midline using the endothermy needle (Fig. 78 (b)). The latter method has the advantage of not dividing so many of the veins which are disposed mainly vertically Stitches previously placed on either side of the proposed line of incision serve as retractors and obviate the need for special T-shaped capsule forceps; one through the capsule at the lower part of the vertical incision serves to mark its lower limit and to control bleeding. The field is kept clear by suction.

Incision of capsule

The incision is carried through the whole thickness of the capsule until the enlarged prostate is seen (Fig. 78 (c)) The flaps of capsule are undermined with scissors curved on the flat in order to start the enucleation. It is completed by the finger and proceeds from the lower poles upwards. The anterior wall of the urethra is deliberately divided in order that the finger can be introduced and an intra-urethral enucleation carried out, sparing the mucous

Enucleation

Excision of shelf

membrane and muscle forming the apex of the trigone is cut away, the edge of the cavity is trimmed, bleeding points are picked up and stitches put in around the rim of the cavity. Drainage is by urethral catheter and suprapubic tube, the latter being smaller than that used by Freyer owing to the more efficient haemostasis. The tube is removed in about 4 days and the catheter in 7 days.

(iii) *Harris's operation.*—In the Harris operation the skin incision is usually transverse, the recti being separated vertically. The bladder is left empty before the operation starts.

Enucleation is started within the urethra, the forefinger passing down to the lowest point of each lateral lobe in turn and breaking through backwards along an oblique line which passes above the verumontanum before sweeping around the lateral lobes. In this way the mucous membrane of the urethral

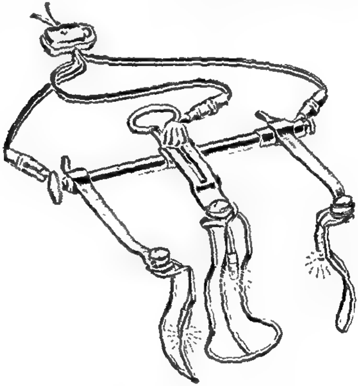


FIG. 76.—Morson's illuminated bladder retractor.

floor below the verumontanum is not removed. An illuminated retractor is inserted (Fig. 76), tags in the cavity are removed, and the shelf of tissue forming the apex of the trigone is stitched down to the urethral floor. This is done by means of a boomerang needle which enters in the midline just behind the inter-ureteric bar and emerges in the floor of the urethra. Besides giving a new covering of mucous membrane for the urethral floor this retrigonization stitch has considerable haemostatic effect. Other bleeding points are picked up and secured by ligation. Two anterior transverse obliterative stitches are then passed across the front of the prostatic cavity in order to approximate its walls, leaving room for the forefinger to pass into the new urethra behind. A thin-walled rubber catheter (size 20 (F.)) is passed along the urethra and anchored in position by a stitch which is brought from the tip

Retrigonization stitch

Transverse stitches

of the catheter through the abdominal wall and fastened by a button, glass rod or rubber tube (Fig. 79) The bladder is closed completely but a small pre-vesical drain is inserted for 48 hours. The catheter is removed in from 7 to 10 days.

(iv) *Wilson Hey operation.*—Apart from his advocacy of a one-stage operation for all cases, Wilson Hey stresses the vital importance of strict asepsis *Asepsis* throughout. After the removal of the prostate the patient is tilted into the Trendelenburg position and the trigone is liberally excised up to the inter- *Trigonectomy* ureteric bar and ureteric orifices. All tags in the cavity are removed and meticulous haemostasis is achieved by sealing all bleeding points with diathermy. *Haemostasis* A catheter is passed from the prostatic cavity outwards along the urethra to *Drainage* avoid introducing infection from without, and the bladder is closed completely. The catheter is removed on the second day or earlier.

(*b*) *Retropubic prostatectomy*

Millin's operation.—In 1945 Millin introduced a route of approach to the prostate below the bladder. The bladder is left empty after the preliminary cystoscopy; the skin incision is vertical or transverse, the recti being separated vertically. The retropubic space is opened up with the forefinger; the bladder is pushed upwards and backwards and held in this position by a

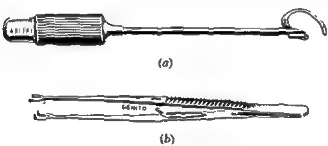


Fig 77.—(*a*) Blunt boomerang needle, (*b*) ligature carrier

retractor. In front of the prostatic capsule is the fatty pelvic fascia containing large friable veins. These are underrun with a blunt boomerang needle and tied before being divided (Fig. 77) The fascia is then displaced laterally by packs inserted into the recess on each side of the prostate. The prostatic capsule is now displayed and is to be divided (Fig. 78 (a)) This may be done *Incision of* transversely, with a small long-handled scalpel as advised by Millin, or ver- *capsule* tically in the midline using the endothermy needle (Fig. 78 (b)). The latter method has the advantage of not dividing so many of the veins which are disposed mainly vertically. Stitches previously placed on either side of the proposed line of incision serve as retractors and obviate the need for special T-shaped capsule forceps, one through the capsule at the lower part of the vertical incision serves to mark its lower limit and to control bleeding. The field is kept clear by suction

The incision is carried through the whole thickness of the capsule until the enlarged prostate is seen (Fig. 78 (c)). The flaps of capsule are undermined with scissors curved on the flat in order to start the enucleation. It is com- *Enucleation* pleted by the finger and proceeds from the lower poles upwards. The anterior wall of the urethra is deliberately divided in order that the finger can be introduced and an intra-urethral enucleation carried out, sparing the mucous

canal below the verumontanum. As the prostate is turned upwards into the prevesical space (Fig. 78 (d)) it is usually possible to recognize and clamp the main leash of vessels entering it on either side; they can be sealed with diathermy.

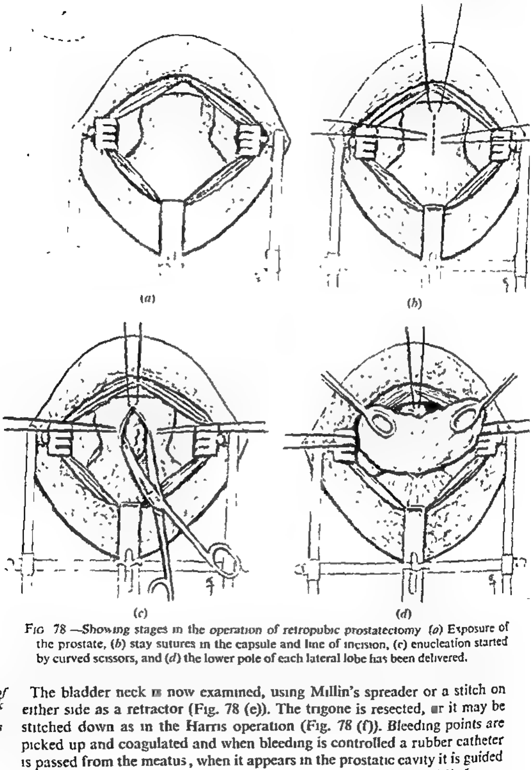


FIG. 78.—Showing stages in the operation of retropubic prostatectomy. (a) Exposure of the prostate, (b) stay sutures in the capsule and line of incision, (c) enucleation started by curved scissors, and (d) the lower pole of each lateral lobe has been delivered.

Treatment of bladder neck

Haemostasis

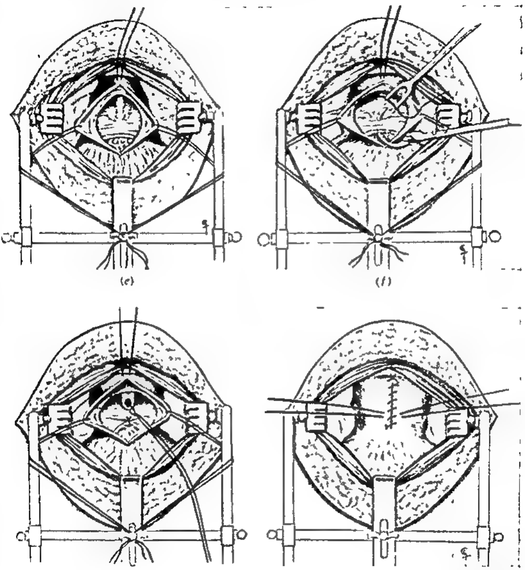
Drainage

The bladder neck is now examined, using Millin's spreader or a stitch on either side as a retractor (Fig. 78 (e)). The trigone is resected, or it may be stitched down as in the Harris operation (Fig. 78 (f)). Bleeding points are picked up and coagulated and when bleeding is controlled a rubber catheter is passed from the meatus, when it appears in the prostatic cavity it is guided onwards into the bladder, with the eyes suitably placed (Fig. 78 (g)). It may

be anchored by ■ sling stitch as described for the Harris operation (Fig. 79) or by being stitched to the penis at the end of the operation.

Closure of capsule

The prostatic capsule is now closed by a continuous stitch of No. 1 chromic catgut using the boomerang needle. The stay sutures inserted earlier are tied



(e) (f) (g) (h)

FIG 78 (*cont*) —(*e*) Long stitches passed under the side bars of the retractor display the prostatic cavity, (*f*) the trigone ■ resected or may be stitched to the floor of the cavity, (*g*) the catheter is held by a stitch which is subsequently passed through the bladder wall by a perineum needle, and (*h*) the capsule is closed by a continuous stitch.

together to reinforce the suture line; the lowest stay suture is also tied (Fig. 78 (h)). The catheter is syringed with citrate solution to dislodge any clots and to test the watertightness of the suture line; the lateral packs are removed and the wound is closed with ■ small pre-vesical drain (Fig. 79). Four ounces of sodium citrate solution (3 8 per cent) are left in the bladder, the

After-care

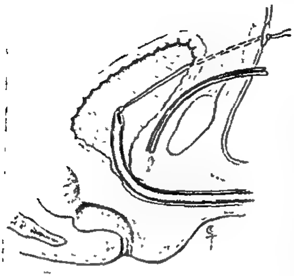


FIG. 79.—The method of anchoring the catheter and the site of the pre-vesical drain.

spigot being removed from the catheter after 1 hour. Aspiration or small injections are needed to keep the catheter clear. It is usually removed on the second day but should be left in longer if clotting still occurs.

Adherent prostate

Carcinoma

This operation follows the most direct route to the prostate and gives the best view of the prostatic cavity of any yet devised. If the gland proves to be adherent, as in a fibrous or calculous prostatitis, it can be dissected out of the capsule with scissors. In a malignant case the same procedure can be adopted and, if the growth

Total prostatectomy

is sufficiently localized, the whole gland with its capsule and the bladder base and seminal vesicles can be removed. The bladder is then anastomosed to the distal cut end of the urethra. The operation thus offers an alternative to the perineal route for radical prostatectomy in cases of carcinoma without extensive infiltration

(c) *Second-stage operations*

In the presence of a cystotomy any of the suprapubic operations or the retropubic operation can be done, and the procedure is straightforward provided that the fistula is sufficiently remote from the symphysis. After suprapubic catheterization, carried out in the manner described, the exposure is as good as in a one-stage operation. For a suprapubic operation the fistula is enlarged downwards; for a retropubic operation it can generally be neglected, all incisions being made below it.

If the fistula is low or there is much fibrosis around it excision of the track is necessary for a good exposure.

(d) *Perineal prostatectomy*

With the patient in an exaggerated lithotomy position a metal bougie is passed. A curved incision is made $1\frac{1}{2}$ inches in front of the anus and the bulb is exposed Dissection proceeds in the space between the bulb in front and the rectum behind, the central tendon and recto-urethralis being in turn divided until the posterior surface of the prostate covered by Denonvilliers's fascia is exposed. The membranous urethra is opened, the urethral bougie removed, and Young's two-bladed tractor passed through the opening into the bladder. This enables the posterior surface of the prostate to be drawn downwards and forwards. An inverted V-incision is made in the prostatic capsule and the lobes are enucleated separately or in one piece Bleeding is controlled by ligatures and by gauze packing, and drainage is provided by a tube passed into the bladder.

In this operation great care must be exercised to avoid injury to the rectum and to the bulbo-cavernosus. Rectal fistula and incontinence of urine are complications of the perineal operation, and therefore it should be undertaken only by those with special experience; its advantages, without the risk of these complications, are obtained by the retropubic approach.

(5) Factors common to all operations

Local chemotherapy

In all open operations full use may be made of sulphonamide insufflation of wounds and cavities, with or without penicillin There is also scope for the newer haemostatics such as thrombin (topical), fibrin foam or gelatin sponge, and absorbable cellulose.

Local haemostatics

Vaso-ligation

Ligation and division of the vas on each side is advised in any open prostatectomy and in some per-urethral operations Without it the incidence of post-operative epididymitis is about 20 per cent. Even after vasectomy rare cases occur but they pursue a milder course.

Histological examination

Every prostate or portion of it removed must be examined histologically.

(6) Post-operative care

Treatment of shock

Prostatectomy may be accompanied by considerable loss of blood and by shock; suitable blood or plasma for transfusion should therefore be available. After the modern operations the general condition does not, as a rule, give rise to undue anxiety, and routine resuscitative measures are not needed.

Strict asepsis must be maintained in all irrigations or dressings.

Irrigation

The greatest care is needed to see that any catheter or tube in the bladder is kept patent. As there is little secretion of urine for the first few hours this entails the use of a syringe; how often it should be used cannot be laid down as a routine but varies with each case, and much depends on the skill and experience of the nurse. Indications for irrigation of the catheter are cessation of drainage and excessive pain A 2-ounce Canny Ryall type of syringe which can be autoclaved is suitable; one should be kept in antiseptic lotion for each patient and should be discarded when the rubber begins to get rough. The usual solution is 3 8 per cent sodium citrate, on the assumption that it is being used solely to prevent clotting. If the catheter does become blocked a more powerful bladder syringe is required (Fig. 74); should this fail and the catheter is known to be in the right position, the instillation of 1 ounce of glycerin of pepsin, which is left in for half an hour, will often clear it (Riches, 1936).

Clot retention

If a catheter or drainage tube is left in the bladder beyond the period of bleeding for other reasons, routine lavage with antiseptics may be required.

Chemotherapy

Sulphonamides (0 5 gramme) and penicillin are continued 6-hourly for about 5 days, the doses being spaced so as to give the minimum disturbance in the night.

After recovery from the anaesthetic the patient is made to drink, at first in frequent small amounts, and later copiously.

Liquid paraffin, ½ ounce three times daily, is started on the day after operation, and an aperient such as cascara is added to it on the second evening. A small glycerin enema is sometimes needed. The man is allowed up to use the commode even on the day after operation; the discomfort of the bed-pan is avoided In any case the patient should sit out of bed after 48 hours and this is the greatest safeguard against abdominal distension as well as against

Early movement

pulmonary complications. Breathing exercises are resumed on the day after operation and leg movements are encouraged from the beginning.

Removal of catheter

The catheter can generally be removed after 48 hours unless there is still clotting; it is not necessary to wait until the urine is quite free of blood. The longer the catheter is retained the greater is the certainty of infection.

The pre-vesical drain is shortened on the second day and removed on the third or fourth day, according to the amount of discharge.

Clips are taken out on the fifth day and stitches, if any, on the eighth day. About this time the patient is ready to go to the bath.

Catheterization

It is sometimes desirable to pass a bicoudé catheter on the tenth day to estimate the residual urine, to ensure that there is no bladder-neck obstruction and to obtain a specimen for bacteriological control. If infection is still present appropriate treatment can be resumed.

Duration of stay in hospital

The patient is generally ready to go home on the fourteenth to the sixteenth day, by which time the danger of secondary haemorrhage is remote. If any urinary infection remains he is given hexamine or Pyridium for a few weeks. He is seen again after 2 months and if the stream is not satisfactory a catheter or bougie is passed.

This is the usual programme after the retropubic operation or the Harris operation with closure. It may be modified after other methods, and is prolonged after a two-stage operation and greatly so whenever a large suprapubic tube has been found necessary. In such cases a well-fitting Hamilton Irving box is worn until the fistula has healed.

(7) Complications

(a) *General*

Prostatectomy is not exempt from the complications inherent in any abdominal operation and the age group to which most prostatic patients belong increases their tendency to complications. Whilst the modern methods are less often followed by complications than the older ones each new operation tends to have special complications of its own.

(b) *Respiratory*

Pneumonia, pulmonary collapse and pulmonary embolism are all reduced in frequency by adequate pre-operative preparation and breathing exercises, by suitable anaesthesia and by early post-operative movement and rising. Treatment of embolism is the immediate administration of heparin intravenously (150 milligrams, 4-hourly). Dicoumarol may produce dangerous haematuria.

(c) *Cardiovascular*

The risk of cardiac complications can be foreseen and sometimes prevented by thorough pre-operative examination by a cardiologist. The previous occurrence of coronary thrombosis is not necessarily a bar to an essential operation, although the liability to a recurrence is greater than in the normal patient.

Cardiac failure

Auricular fibrillation or cardiac failure interferes with the early ambulation generally advocated.

If the blood-pressure has fallen considerably during the operation more bleeding must be anticipated when it rises, increased vigilance by the nurse with the syringe is necessary.

Transient oedema of the penis from ligation of the connexions of its dorsal vein is occasionally seen after the retropubic operation.

(*d*) *Intestinal*

Ileus, which was a frequent complication of the older operations, is rarely seen now; adequate but not drastic pre-operative measures, a transverse incision and early post-operative movement prevent it, but it may be a manifestation of uraemia.

Acute dilatation of the stomach occurs at times and calls for the use of a Ryle's tube with suction.

(*e*) *Renal*

Post-operative uraemia may follow prostatectomy in the presence of damaged kidneys and the absence of pre-operative drainage. An infective element is also present, leading to pyelonephritis. Treatment is by the intravenous infusion of isotonic sodium sulphate (4 3 per cent) and the administration of sulphonamides and streptomycin; the outlook is grave.

(*f*) *Infective*

Infections remain the most frequent complications although their incidence has fallen with chemotherapy. Local sepsis in the prostatic bed is very common, especially if blood clot is allowed to collect there. It is the cause of secondary haemorrhage which may appear about the sixth day or earlier. *Secondary haemorrhage*
Should this occur chemotherapy is resumed and the bladder may have to be emptied of clots. This can generally be done through a urethral catheter, especially when aided by glycerin of pepsin. If the catheter fails, Freyer's evacuator with a large cannula can be used under an anaesthetic. In a few cases the bladder must be opened. Subsequent lavage helps to check further bleeding. Morphine should be given and Hemoplastin (2 cubic centimetres intramuscularly) often acts well and may be repeated. Frequent blood-pressure readings should be taken and blood transfusion should be given in serious cases. Clot retention does not follow every secondary haemorrhage, and the less serious cases clear up without instrumentation.

Local sepsis is also the starting point of ascending renal infection and of descending infection of the vas and epididymis. Acute epididymitis is rare *Epididymitis*
after vasectomy but local abscess at the site of the section will indicate infection in the prostatic bed. Such cases are also liable to infection of the seminal vesicles, which is a cause of persistent chronic urinary infection; removal of the vesicles at the time of prostatectomy has much to recommend it.

Spread beyond the confines of the prostatic bed may produce pelvic cellulitis. In the Harris operation too deep a bite for the retrigonization stitch has been blamed (Jacobs, 1937). In the retropubic operation the cave of Retzius is deliberately opened, and infection here may cause delay in healing.

Of more serious import is the low-grade infection of the pelvic girdle which *Osteitis pubis*
may result from lymphatic spread in pelvic cellulitis, or from injury to the periosteum by a needle: it is fortunately of rare occurrence. The condition becomes manifest some weeks after operation; there is pain in the perineum and over the symphysis and buttocks, and inability to walk. Tenderness is found along the ischio-pubic rami and ischial tuberosities. Skiagrams show a widening of the symphysis pubis and patchy rarefaction in the pelvic bones

FIG. 80.—Osteitis pubis, there is destruction of the symphysis and rarefaction of the ischio-pubic rami.

—particularly the ischial tuberosities and ischio-pubic rami (Fig. 80). Urinary infection may be absent. Treatment by large doses of vitamin B both by mouth and by injection, combined with short-wave diathermy, has been found effective (Lavalle and Hamm, 1949). Without such treatment the condition may take many months to resolve.

Urinary infection

Persistent infection of the urine is not uncommon. In the absence of obstruction the condition tends to clear up spontaneously, or when aided by appropriate chemotherapy. Streptomycin is valuable for *Bacillus coli* and *B. pyocyaneus* infections and penicillin for staphylococcal infections. *B. proteus* remains the most resistant organism. A long-standing pre-operative infection is difficult to eradicate.

Generalized infection

General septicaemia has been encountered, mostly after endoscopic resection in infected cases treated without suprapubic drainage. Cavernous sinus thrombosis is not unknown.

Persistent fistula

Failure of closure of a suprapubic fistula is due to infection, urethral obstruction, fibrosis of the track or muco-cutaneous union, these factors are all accentuated if the fistula is low and the bladder contracted.

Urethral infection may follow catheter drainage with improper care of asepsis and lead to cellulitis of the penis or peri-urethral abscess. A mild degree of urethritis is inevitable with an indwelling urethral catheter and can be controlled by chemotherapy, but in a more serious degree the catheter must be removed and some other form of drainage substituted.

Inflammatory complications due to pre-existing infection

The post-operative inflammatory complications vary in incidence with the pathological type of prostate, being less frequent with the adenomatous gland than the fibrous gland, and most common in calculous prostatitis (Riches and Muir, 1933) They must, therefore, be due in some measure to pre-existing infection, but this does not absolve the surgeon from practising strict asepsis before, during and after operation.

(g) *Neurological*

(i) *Obturator neuritis.*—Injury to the obturator nerve has been reported after the retropubic operation; it is probably caused during the placing of the lateral packs. It produces pain in the medial side of the thigh and spasm of the adductors. Spontaneous recovery after some months is the rule.

(ii) *Atonic bladder.*—The persistence of residual urine amounting at times to retention may be due to bladder atonicity; it is most common after a

one-stage operation in the presence of chronic retention. The treatment is by repeated catheterization together with the administration of carbachol (oral), 1–4 milligrams twice daily, until muscular tone recovers. A bladder that has been overstretched for a long period may never recover completely.

(iii) *Incontinence.*—Transient loss of control may follow the use of an over-distended balloon catheter. Complete incontinence in the absence of a nerve lesion is generally due to damage to the membranous urethra It is commoner after endoscopic resection than open operation and may be transient from overstretching of the sphincter, or permanent from too low a cut It occurs more frequently in malignant cases, in which there is often infiltration in the region of the sphincter, and after perineal rather than suprapubic prostatectomy. It may be due to incomplete removal of the prostate, or to deep peri-prostatic infection.

Millin (1947) has devised an operation for its cure using ribbon catgut to narrow the bulbous urethra.

(h) Post-prostatectomy obstruction

Recurrence of difficulty or even retention is a most disappointing sequel of any operation undertaken for its relief. The possible sites of fresh obstruction are the internal meatus, the prostatic bed, the membranous urethra and the anterior urethra

Internal meatus

At the internal meatus it may be due to shelf formation (Fig 81). It is prevented by resection of the trigone or the Harris retrigonization stitch. It can be cured by a small endoscopic resection after dilatation of the internal meatus to allow the instrument to pass.

Reappearance of prostate

Reappearance of the prostate is the rule after suprapubic enucleation of a glandular prostate as the compressed posterior lobe re-expands In the course of years it may produce a new obstruction and a second prostatectomy may be required Recurrent obstruction may follow earlier if isolated adenomas are left behind (Morson, 1937), but it is more likely after the removal of a fibrous or calculous infected prostate when the whole cavity may become filled with fibrous tissue. Recurrence of a malignant prostate is to a large extent checked by the continued use of stilboestrol

FIG 81.—Post-prostatectomy shelf formation and obstruction, urethrogram

FIG. 82.—Mushroom stone in the prostatic cavity and bladder

In infected cases a stone of the mushroom type may form and block the outlet (Fig. 82).

Recurrent obstruction in any type will in time occur after inadequate endoscopic resection.

Membranous urethra

Removal of the mucosa of the membranous urethra will be followed by stricture. Intra-urethral enucleation from below upwards prevents this mistake. The incontinence caused through injury to the membranous urethra by faulty endoscopic resection is sometimes followed by stenosis at a later date, a period of apparent cure being succeeded by renewed difficulty.

Anterior urethra

Stricture of the anterior urethra will be severe if a large electrotome is forced through a narrow urethra. Such longitudinal strictures respond badly to dilatation and permanent perineal urethrostomy may be necessary.

Stenosis of the external meatus is sometimes caused by an indwelling catheter. When the opening is narrow a formal meatotomy, with suture of the edges, should be performed.

11. RESULTS OF TREATMENT

(1) General effects

Despite the formidable list of possible complications prostatectomy is a most satisfactory operation. Life is prolonged and is made comfortable; the fear of acute retention is removed and the consequent mental relief is associated with increased physical vigour. The effect on sexual potency is variable.

Under favourable conditions the stay in hospital is little more than a fortnight and many men are ready to return to work a few weeks later. The operation has been robbed of most of its terrors in the way of post-operative pain.

Requisites for success

To attain this result it is necessary for certain conditions to be fulfilled, some of which are under the control of the patient and some under the control of the surgeon. The patient must come for treatment reasonably early, before the onset of chronic retention or infection. The surgeon must be prepared to conduct the management of the case as well as the actual operation. Whatever operation is performed the fundamental needs are the avoidance of urethral damage, the exclusion of infection, and strict haemostasis; the operation should be one which under these conditions allows of safe closure of the bladder.

The avoidance of post-operative urinary infection will reduce morbidity.

It is possible with modern chemotherapeutic aids to maintain a bacteriologically sterile urine throughout treatment and this has been done in a number of cases. Attention to detail is needed; such things as the size or composition of a catheter or the number of its eyes may make all the difference between a good result and a bad one.

Per-urethral operations

The period of hospitalization after a per-urethral operation may be a little shorter but post-operative complications are apt to be more frequent if it is used for all types of prostate. While the final results are often excellent the attainment of a good functional result with clear urine takes longer to achieve than after open operation. There is too often a residuum of devascularized tissue which maintains infection, and a "relatively prolonged post-operative urethral morbidity" (McCarthy, 1948).

(2) Mortality

Per-urethral operations

The mortality rate of per-urethral operations varies enormously in different clinics and is lower in the hands of the expert urologist than in those of the general surgeon.

Nesbit (1943) recorded a mortality of 2·1 per cent in 1,000 cases, secondary resection was required in 3 per cent Barnes (1942) estimated the death rate from resection throughout America as around 5–6 per cent. Thompson (1940) reported a mortality of 0 9 per cent in 1,000 cases at the Mayo Clinic. In Great Britain, Wardill (1946) reported a 13 per cent mortality in 236 patients whose average age was 71 years, and Stewart (1945) one of 3 7 per cent in 621 cases.

Open prostatectomy

Freyer (1920) had a mortality of 5 3 per cent in 1,625 prostatectomies, but in the hands of general surgeons several series with a mortality of about 20 per cent have been reported.

Thomson-Walker (1930) found the mortality in 3,451 cases done at eleven general hospitals to be 19 5 per cent, in St. Peter's Hospital it was 9 9 per cent in 2,691 cases, and in his private practice 6 08 per cent in 608 cases.

Harris (1934) in a 5-year period had 2 7 per cent of deaths in 317 cases. Galbraith (1948) reported a mortality of 3 7 per cent in 318 cases treated by the Harris operation.

Wilson Hey (1945) reported 6 per cent of deaths in 335 patients; in those with a blood urea of less than 80 milligrams per 100 cubic centimetres it was 3 4 per cent

Millin (1948), reporting the results of the retropubic operation by 16 different surgeons, found a mortality rate of 5 3 per cent in 1,503 cases.

Young (1936) had a mortality of 3 5 per cent in 3,500 cases of perineal prostatectomy, in other surgeons' hands it was higher.

Suprapubic cystotomy

The mortality of suprapubic cystotomy as a first-stage operation is likely to be high as the patients chosen for this procedure are the bad-risk cases; it was 28 per cent in 106 cases at a general hospital (Rees, 1947). This writer also confirmed that sepsis in the urinary tract was the most frequent cause of death after operation.

Expectation of life

In the age group of the prostatic patient the expectation of life is in any case not great, but it can be prolonged in comfort by timely surgical treatment. Long-term survival depends largely on the state of the cardiovascular system.

REFERENCES

Barnes, R. W. (1942). *Endoscopic Prostatic Surgery*. London; Kimpton.

Batson, O. V. (1940) *Ann Surg*, **112**, 138.

Dodds, E. C., Goldberg, L., Lawson, W., and Robinson, R. (1938) *Nature, Lond*, **141**, 247

Fergusson, J. D, and Pagel, W. (1945). *Brit. J. Surg.*, **33**, 122.

Freyer, P. J. (1920). *Clinical Lectures on Enlargement of the Prostate*, 5th ed. London; Baillière

Galbraith, W. W. (1948) *Proc. R. Soc. Med.*, **41**, 73.

Harris, S. H (1934). *Brit J. Surg.*, **21**, 434.

Hey, W. H (1945) *Brit J. Surg*, **33**, 41.

Huggins, C, Scott, W. W., and Hodges, C. V. (1941). *J. Urol*, **46**, 997.

Jacobs, A. (1937). *Proc. R. Soc. Med*, **30**, 1232.

Kretschmer, H. L., and Squire, F. H. (1948). *J. Urol.*, **60**, 1.

Lavalle, L L., and Hamm, F C (1949). *J. Urol.*, **61**, 83.

Marion, G. (1921). *Traité d'Urologie*. Paris; Masson.

McCarthy, J F. (1948). *J Urol.*, **60**, 138.

Medicine and the Law (1948). *Lancet*, **2**, 232.

Millin, T. (1945) *Lancet*, **2**, 693.

— (1947). *Retropubic Urinary Surgery*. Edinburgh, Livingstone.

— (1948). *J. Urol.*, **59**, 273.

Morson, A. C (1937) *Proc. R Soc Med*, **30**, 1224

Muir, E G (1934) *Lancet*, **1**, 667

Nesbit, R M. (1943) *Transurethral Prostatectomy* Springfield, Ill ; Thomas

Rees, W. S. (1947). *Brit. J. Urol.*, **19**, 83

Riches, E W. (1936). *Brit med. J.*, **1**, 578

— (1943) *Lancet*, **2**, 128

— (1948) *Textbook of Genito-Urinary Surgery*. Ed by H P. Winsbury-White Edinburgh; Livingstone

— and Muir, E. G. (1933). *Brit. J. Surg.*, **20**, 366

— and Robertson, J. D. (1935) *Brit. J. Surg*, **23**, 128

Sandrey, J G (1949). *Post-Grad med J*, **25**, 71

Squier, J. B. (1913). *Trans. Amer. Ass. gen-urin. Surg.*, **8**, 218.

Stewart, H. H (1945). *Brit med. J*, **2**, 724.

Thompson, G J. (1940) *Proc. Mayo Clin.*, **15**, 783.

Thomson-Walker, J W (1920) *Brit J Surg.*, **7**, 526.

— (1930). *Trans. med. Soc., Lond*, **53**, 206.

Walters, G. A. B (1948). *Brit. med J.*, **1**, 638.

Wardill, W. E. M. (1946). *Trans med Soc., Lond*, **64**, 272.

Young, H. H (1936). In *Modern Urology*. Ed by H Cabot, Vol I, p. 756 Philadelphia, Lea

[References to other titles are given under Prostate in the Index Volume. The subject is also dealt with under the heading of Prostate Diseases in the *British Encyclopaedia of Medical Practice* (1938), Vol 10, p 146]

PROTRACTED ILLNESS—MANAGEMENT AND REHABILITATION

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1. DEFINITION

279.] The term, protracted illness, is used here to describe conditions which need continuous treatment for long periods of time before recovery can be established. The term also includes conditions which, though incurable, need prolonged care and supervision both for the comfort of the patient and in order to retard deterioration

2. AETIOLOGY

Protracted illness may occur at any age, and in either sex, but for physical, psychological and social reasons it is most frequently found amongst the elderly. The following are the causes. *Age and sex incidence*

(1) Any condition which, by reason of its nature, responds slowly to treatment.

(2) The presence of multiple sources of illness, whether disease or trauma.

(3) Incurable conditions which require prolonged supervision and medical care.

(4) Mismanagement or under-treatment of any patient during a period of rest in bed, for whatever reason.

3. PROGNOSIS

General management of patient

Apart from the major condition present, the general management of the patient as a whole is the most important single factor upon which prognosis depends. Age alone need play only a small part in considering surgical treatment as the elderly, in the hands of experts, withstand modern surgical technique and anaesthesia well. Every case of protracted illness, however, is complicated by both physical and psychological states which must be recognized and treated by the surgeon if the best results are to be achieved.

4. POST-OPERATIVE MANAGEMENT

Concurrent diseases

The presence of concurrent diseases, especially in the elderly, constitutes a serious handicap to the normal rate of recovery following an accident or a surgical operation. Unless convalescence is carefully managed, the chances of recovery may be seriously prejudiced. In order to implement full treatment, team-work is needed and the services of the physiotherapist, the occupational therapist and the almoner (medico-social worker) should be recruited, in addition to those of the medical and nursing personnel.

Continuity of treatment

Continuity of treatment is important and the patient should be kept in an active unit until rehabilitation has been established to the fullest possible extent. The surgeon should, therefore, decide early whether the patient will remain in his unit to complete the treatment, however long this may take, or whether, after consultation with a physician interested in the treatment of protracted disease, he will transfer such a patient to a medical ward immediately the surgical procedure is complete.

Within this framework the management of such patients falls under the following headings.

1. Surgical treatment, which is dealt with in the appropriate section.
2. General treatment, including: (a) physical care; (b) psychological care.
3. Treatment for the prevention or cure of those conditions which may develop after prolonged periods of rest in bed
4. Sustained planned supervision for the incurable patient.

Responsibility of the surgeon

In this connexion it should be remembered that inability on the part of the surgeon to cure quickly or to cure at all in no way relieves him of his responsibility to the patient, who may still need surgical supervision and careful planning for his comfort, and to prevent further deterioration.

5. GENERAL TREATMENT

(1) Physical care

The physical care of the patient includes:

(a) Care whereby the patient may be kept as independent and mobile as possible

(b) Treatment, as required, of concurrent diseases, for example, arthritis, cardiac lesions, hemiplegia and the like.

(c) Attention to diet.

(d) Attention to sleep and rest.

(a) Encouragement of independence and mobility

Even while in bed the patient should be encouraged to move about and to exercise his joints regularly. Unless there is some special contra-indication he

(b) Treatment of concurrent conditions

Treatment of concurrent conditions must be carried out actively in the post-operative period, if normal progress is to be maintained. For example, a hemiplegic patient under treatment for a fracture must be actively treated, in anticipation of the day when the fractured bone has united sufficiently well to bear weight once more, and it is important that a patient confined to bed with arthritis or Parkinson's disease should be supervised very carefully to prevent increased stiffness and contractures.

(c) Attention to diet

Diet is an important item in the life of a patient who needs treatment for a long period of time. Variety, quantity and quality matter very greatly to one who has little except meals with which to punctuate his day. The dietary needs of people vary very greatly and, in illness, every effort should be made to give a patient as nearly as possible what he likes as well as what he needs. A good ward-sister will do well to study the personal whims of her patients in this respect.

Attention to personal whims

With elderly patients whose dental conditions are below standard, it will be found beneficial to have meat minced, and vegetables, especially greens, made into a purée. Without these precautions much food may be wasted owing to the patient's inability to masticate well. Elderly folk frequently prefer food that is highly seasoned or spiced, and often demand extra sweetening, which should be given whenever possible. It is a common fallacy that elderly patients have small appetites; on the contrary, many eat large quantities of food and greatly enjoy tasty meals. On the whole the elderly are more fastidious concerning food than are younger patients.

(d) Attention to sleep

Attention to sleep is one of the most neglected items in the care of a patient who remains in hospital for a long time. It should be remembered that the natural incentives to sleep are physical and mental fatigue. For many reasons it is desirable that a patient should sleep by night. If he does not, the long wakeful hours at night are irksome to him and, in his wakefulness, he may well disturb other patients. Unless he secures a continuous period of sleep he will not be satisfied, and will be unconvinced when told that he has in fact had sufficient sleep during the 24 hours.

Natural inducement of sleep

The most satisfactory method of inducing sleep is to ensure physical and mental activity during the day. Methods of ensuring adequate physical activity have already been referred to and ways of encouraging mental activity will be mentioned in the section dealing with psychological care. Before drugs are resorted to, every effort should be made to induce sleep by natural means. Large meals late in the day should be avoided. The patient should be warm and comfortable, with dressings, bandages and appliances attended to Attention to the functions of the bladder and rectum should also be assured, as an overloaded viscus can give rise to much nocturnal restlessness. The room or ward should be well ventilated, as dark as is convenient, and as quiet as is possible.

Hypnotic drugs

If, however, all these methods fail and hypnotics cannot be avoided, then the smallest effective doses should be given, and these should be administered early in the night so that the patient has a chance to sleep well during the quiet

hours. If given too late or in unnecessarily large doses, such drugs tend to produce drowsiness by day with the consequent disadvantages that the patient will not take diet well, will be unable to take part in his rehabilitation and, by the evening, will be awake again and unable to settle down without more drugs.

Other disadvantages of the regular use of hypnotics are seen in the countless untoward symptoms initiated, including the psychological need of "a drug to sleep".

Probably the best hypnotics to use are bromides alone or in combination with chloral hydrate, paraldehyde, or one of the barbiturates. Except as a last resort, the parenteral administration of drugs should be avoided, as many patients become dissatisfied with drugs given orally, once they have had "a prick". Morphine should *never* be given merely to induce sleep.

(2) Psychological care

Most patients suffering from protracted illness have some anxieties concerning health, social economy or fears for the future, and such psychological factors need careful investigation and treatment. It is important to initiate mental activity of a pleasant and absorbing nature, so creating good morale and a co-operative spirit; it is important also to allay fears and apprehensions on the part of the patient concerning his health, welfare and future, which, if unchecked, will play a sinister role in delaying progress or preventing recovery. *The value of absorbing mental activity*

Pleasant mental activities may be initiated by paying attention to visiting, providing access to wireless programmes, suitable reading books, newspapers and so forth, and ensuring the correct psychological approach of every person who tends the patient in any capacity whatsoever.

In addition, diversional and occupational therapy have much to offer in interesting a patient by helping him to concentrate on constructive work, and keeping him happily engaged during a prolonged period of inactivity. *Diversional and occupational therapy*

With the elderly, anticipated changes in the mode of life with possible loss of independence resulting from impaired health, or lack of means to maintain a previous standard of living, are very real factors bearing a definite relationship to the total length of illness as well as to the infirmity. *Retarding effect of apprehension*

As illustrations of these fears a few examples will suffice.

(a) Colostomy for malignant disease may preclude an old man from returning to his lodgings and so he will try to postpone the day when he must enter an institution.

(b) Amputation of a leg for arteriosclerotic gangrene may render a previously frail old woman too feeble to continue living with relatives. A hospital ward may seem to offer a better future than does a residential home.

(c) An arthritic patient who has fallen repeatedly may finally be regarded as unsuitable to return to full independence after a major fracture and, unless such an individual is treated psychologically during convalescence, his progress may be retarded in an attempt to postpone discharge to the care of relatives.

(d) Prolonged inactivity, following a serious surgical procedure, may leave an elderly person physically unfit to return to an independent existence and fear for the future may further retard his progress.

Plans for the future

It is important, therefore, when planning ■ patient's treatment ove period of time to consider his future and discuss plans with him.

Medical aspects of the case will best be dealt with by the surgeoı include the nature of the disease, the hopes for recovery, the duratio ness, the likelihood of recurrence and the final prognosis.

Role of the almoner

The social needs can often be assessed by the almoner in consultati the surgeon. Questions from the patient should be answered simply fully as is deemed wise. These discussions should not be left to junior officers or to nursing staff, although both should be present to hear said. By this means the house surgeon will learn how to advise such a the nurse will learn with the patient what the surgeon expects and ho and the patient will understand the plan which is prepared for his r and the necessity for his co-operation. It is only by team-work of th that the best results can be expected.

6. SEQUELAE OF PROLONGED REST IN BED

Patients, particularly if elderly, when confined to bed for long periods —for whatever reason—unless very carefully treated by preventive me are liable to develop certain untoward sequelae. These sequelae ir (1) stiffness of joints with contractures; (2) disuse atrophy of limbs re from immobility; (3) helplessness, often followed by incontinence of u faeces or both; (4) pressure sores induced by immobility and contra and aggravated by incontinence; (5) obesity following immobility, further increases helplessness, (6) constipation.

FIG 84 —Male aged 74 years, showing fixed contractures in a scissor deformi ... limbs following fracture of neck of left femur. Conditio

■ nursing attendant in a hospital

It is essential that all members of the therapeutic team should thoroughly understand the risks of prolonged rest in bed, and the ways in which such sequelae can be prevented.

Ill effects of a hopeless or apathetic attitude

Development of any of these conditions will hamper progress and bring about a feeling of hopelessness and apathy towards recovery which will soon be reflected in the patient's attitude to treatment. If this state of affairs continues, the chances of recovery may well be wrecked

(1) Stiffness and contractures

Throughout treatment, therefore, patients should be kept as mobile and as independent as possible by the methods already described. If joint stiffness or contractures of limbs have already commenced then active treatment must be started to remedy the condition (Fig 84) The application of local heat, followed by massage and exercises, will probably be found to be the best treatment for this purpose.

(2) Incontinence

A tendency to incontinence must be investigated immediately and any organic cause treated. If an organic cause cannot be found and the incontinence is regarded as functional, then attempts must be made to re-educate the sufferer and so to overcome this distressing complaint. Discussion with the patient may elicit the cause of such incontinence.

Examples of common causes to the condition are: unfamiliarity with nursing routine; modesty or shyness in reporting the normal call to micturition; inability to get attention sufficiently quickly or frequently; laziness on the part of the patient; and mental deterioration.

The first three causes can be remedied by the nursing staff and the last two will often be improved by getting the patient up, seeking his co-operation and giving him more frequent attention.

(3) Pressure sores

Every effort must be made to avoid the development of pressure sores as they cause great distress to the patient, add considerably to the work of the nursing staff, and frequently become as great a handicap to progress as is the original condition for which the patient is under treatment.

Prevention of pressure sores can best be achieved by meticulous attention to nursing care and by the initiation of regular movements, active or passive. (*See* Bedsores, Vol 2, p 65.)

(4) Obesity

Obesity can be prevented by attention to diet, with avoidance of excess carbohydrate, and by as much mobility and exercise as the patient can tolerate.

(5) Constipation

Disadvantages of enemas and aperients

Neither aperients nor enemas are without disadvantages, for both inconvenience the patient, give additional work to the nursing staff, and interrupt rehabilitation Every effort, therefore, should be made to correct constipation by ensuring an adequate fluid intake, by regulation of diet and by the encouragement of greater mobility.

7. THE INCURABLE PATIENT

In the case of the incurable patient there still remains the responsibility of the staff for sustained skilled supervision. There is need:

(1) To retard deterioration and to avoid the development of preventable conditions as previously described.

(2) To encourage the patient and to ensure that his last months or weeks are spent profitably and happily.

(3) To keep him as comfortable and as free from pain as possible.

The management of relief of pain in protracted illness needs much thought and care.

Treatment of pain

Treatment of pain is very important in cases of protracted illness when drugs may be needed for long periods and in increasing doses. It is essential for the patient's well-being that the dosage be increased as slowly as possible, using the less potent drugs first. For instance, pain is relieved adequately in the early stages of malignant disease by a mixture of aspirin and phenacetin in small doses, and later by a combination of these with codeine in the form of Tab. Codein. Co., given occasionally at first, and later 4-hourly. When these measures prove insufficient Dover's powder, 10 grains, or Liq. Morph. Hydrochlor., 15 minims, gradually increasing to 30 minims, may be used, occasionally at first and then 4-hourly.

Finally, when the pain is controllable only by means of hypodermic injections of morphine, then small doses of morphine sulphate, $\frac{1}{8}$ grain, should be tried first and these only gradually increased to $\frac{1}{6}$ grain and $\frac{1}{4}$ grain when necessary; finally this dosage may be required 4-hourly.

Individual control of dosage

By adopting this principle, the choice of drugs, their dosage and their frequency is controlled individually by the patient under the careful supervision of the staff, and massive dosage of a drug such as morphine can be avoided, with considerable advantage to the patient. As morphine is habit forming and, in large or regular doses, is responsible for a number of untoward symptoms, it should always be prescribed with care and then only when other drugs fail to give relief.

[References to other titles are given under Protracted Illness—Management and Rehabilitation in the Index Volume.]

PULMONARY ABSCESS

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1. DEFINITION

280] A lung abscess is a cavity, containing pus, within the substance of the lung, it is essentially a final stage in the development of a suppurative pneumonitis. In some cases the abscess cavity is relatively large and is surrounded by only a thin zone of pneumonitis, and it thus presents as the chief element. In other cases the suppurative pneumonitis predominates and an associated abscess cavity, or several small cavities, must assume a lesser importance. Although many lung abscesses have an offensive odour (foetid, putrid, anaerobic), this is by *no means always so It is important to remember that non-*offensive abscesses (non-foetid, aputrid, aerobic) occur, otherwise the absence of an evil odour may cause the diagnosis to be overlooked.

2. AETIOLOGY

Primary and secondary

It is important to consider the aetiology in every case of lung a
majority (75 per cent) are secondary to an identifiable cause; or
per cent are true primary abscesses. A diagnosis of primary l
should be made only after all attempts to identify a primary cause
This is not only of academic importance but is of great practic
enables one to consider the means of prevention of a lung absce
similar circumstances, and it influences treatment and managemen
ably. Thus, bronchial carcinoma is the primary cause in 10–12
cases and yet is often not even thought of. In contrast an inha
body, which is often regarded as a frequent cause, is responsible i
1 per cent of cases.

(1) Inhalation of infected material

When a cause is identified it will usually be found to be the inh
some form of infected material. Thus the commonest precursor is
tion, especially one on the upper respiratory tract. In the United
America tonsillectomy is a common cause of lung abscess but it is
Great Britain. Tooth extraction is a much commoner cause an
important than is usually supposed; multiple tooth extraction, es
complete clearance in one sitting, is especially dangerous. The us
analgesia does not exclude the risk The time interval (10–20 days
operation or tooth extraction and the development of the lung abs
leads to their association being overlooked

Tonsillectomy

Tooth extraction

(2) Gross dental sepsis

Many so-called idiopathic or primary abscesses are due to gro
sepsis—chronic gum infection with pus pockets and tartar mas
spirochaetes and fusiform bacilli found in the mouth of patients w
dental sepsis are those often found in the foetid lung abscess. Many
lung abscess which follow operations, especially abdominal operat
associated with gross dental sepsis, which is doubtless the actual dete
cause. Attention should, therefore, always be directed to the teeth b
operation; even with an acute abdominal emergency, if circumstances
time is well spent in performing a simple toilet and a scaling of gros
The incidence of lung abscess and serious suppurative pneumonia in
aged men after a perforated peptic ulcer is high enough to justify
badly infected teeth with tartar masses are to be extracted a pre
scaling and cleaning should be done some days before the extraction.

Prophylactic dental toilet

(3) Specific organisms

A lung abscess may be due to specific organisms, such as strept
staphylococci and Friedlander's bacillus, amoebic abscess also occu
most important specific organism is the staphylococcus (Brock, 194
this is a very common infecting organism in infants and children.

is shown in Table I.

TABLE I

AETIOLOGY OF LUNG ABSCESS IN 363 CASES

Cause			No. of cases	Percentage of total
Identified:				
Malignant (bronchial carcinoma)		47		
Non-malignant		222		
			269	74
Obscure, "primary"			94	26
Analysis of non-malignant group (316 cases)				**Percentage of group**
Cause identified:				
Post-operative:				
Abdominal	41			
Non-abdominal (Including tooth extraction, 25 cases; tonsillectomy, 7 cases)	39			
		80		25
Dental sepsis		60		19
Specific infections:				
Staphylococcus	21			
Streptococcus	1			
Friedlander's bacillus	2			
Actinomyces	2			
		26		8
Various causes (Including upper respiratory infection, 16 cases; and lower respiratory infection, 13 cases)		56		18
			222	70
Cause obscure, "primary", cryptic			94	30

3. SURGICAL ANATOMY

A correct understanding of lung abscess, and in particular of its surgery, rests upon a knowledge of broncho-pulmonary segmental anatomy. Indeed, the appreciation of this anatomical approach to many lung diseases has been one of the greatest advances of the last decade.

(1) Broncho-pulmonary segments

The relevant details are shown in Fig. 85, for fuller information the reader should consult the articles and the book on this subject by Brock (1942, 1943, 1944 and 1946) or by Foster-Carter (1942) The simple lateral-view diagrams in Fig. 85 are chosen because in the antero-posterior view so much overlapping occurs as to cause confusion. It will be noted, for instance, that in the right upper lobe there are three main broncho-pulmonary segments; an apical, a pectoral or antero-lateral, and a subapical or postero-lateral. The middle lobe has anterior and lateral segments. The left upper lobe seems complicated because the lingular segment (with its superior and inferior divisions), which represents the middle lobe, is fused with it; otherwise the same three

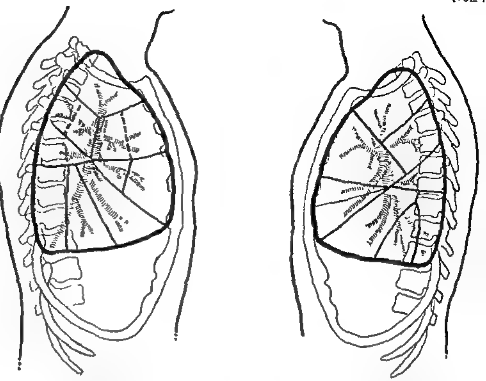


FIG 85 —Diagrams to show the broncho-pulmonary segments and the bronchi supplying them Only the lateral views are given, because so much overlapping occurs in the antero-posterior views.

(2) Localization of the abscess

Relation to segmental anatomy

Almost every lung abscess forms in relation to a segment or a part of a segment, and it is essential to attempt to localize the exact site of the lesion in relation to this segmental anatomy. This can usually be done by a study of postero-anterior and *lateral* skiagrams of the chest; lateral skiagrams are essential. It will be found that lung abscess favours certain sites, notably the subapical or postero-lateral segment of the upper lobes (especially the right) and the apical segment of the lower lobes.

Unless the localization of the abscess is assessed it is not possible to prescribe proper postural drainage and it is quite impossible to plan a correct operative approach if external drainage becomes necessary.

4. PATHOLOGY AND MORBID ANATOMY

(1) Mechanism of production of the abscess

With but few exceptions, the mechanism of production of a lung abscess is bronchial occlusion consequent upon the inhalation of infected material This material enters from the upper air passages and may originate there, for example, tartar, blood-clot, or pus; or it may enter from elsewhere, for example, inhaled vomit, or inhalation during immersion. Occasionally it arises from the lower air passages, for example, in a patient with bronchiectasis.

(2) Progress of the abscess

Once occlusion occurs an acute segmental or subsegmental pneumonitis follows, the intensity of which varies with the nature of the inhaled material

and the virulence of the micro-organisms (Fig. 86 (a)). Thus, infected tartar masses usually carry *spirochaetes and fusiform bacilli*, and an acute foetid abscess with a gangrenous lung slough commonly results. The formation of the abscess cavity with its sloughs is due to thrombosis of the central vessels *Thrombosis of vessels*

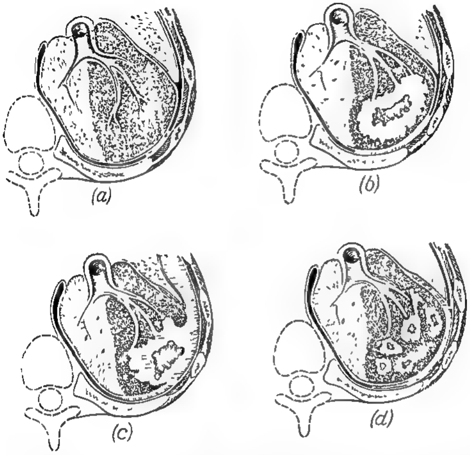


FIG 86.—Diagrams to show various stages of abscess formation: (*a*) Segmental pneumonitis Note early overlying pleurisy (*b*) Abscess formation has now occurred. The cavity contains pus and a slough Note the thin outer layer of live lung and overlying pleural cavity obliteration (*c*) Intrapleural rupture (*d*) Multiple small abscess formation with numerous small sloughs.

supplying the segment; unless the infection is very severe the blood supply of a thin layer of lung under the pleural surface is maintained by the subpleural plexus of vessels; in almost all cases, therefore, the abscess cavity extends to within a very short distance of the pleura (Fig. 86 (b)). There is thus an early pleural reaction and the overlying pleura becomes adherent by the time the abscess cavity has formed In some cases the gangrenous process may involve *Involvement* the pleura, which may rupture if the abscess becomes tense with pus, and *of the pleura* infection of the pleural cavity will follow (Fig. 86 (c)) In some cases multiple small abscesses may appear in the segment (Fig 86 (d)) and may later coalesce to form one or two larger cavities.

(3) Presentation of the abscess

Peripheral presentation

It is of great importance to appreciate this typical presentation of a lung abscess on the pleural aspect of the segment. It means that the lung abscess is *always* peripheral, *never* central or hilar. The misconception of hilar or central abscesses has arisen chiefly from failure to use and study lateral skiagrams. The abscess usually presents on the costal pleura, but it may present on the interlobar, mediastinal, paravertebral or diaphragmatic surface (Fig 87). Even though an interlobar presentation may appear to be deep or central so far as the lung is concerned, it is still peripheral or superficial so far

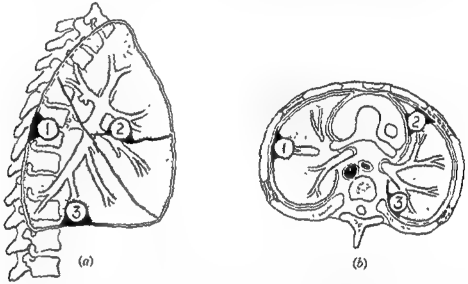


FIG 87.—Diagrams to show the peripheral segmental nature of lung abscess. (*a*) 1: Costal presentation 2 Interlobar presentation 3 Diaphragmatic presentation (*b*) 1: Costal presentation 2. Mediastinal presentation 3 Paravertebral presentation.

as the lobe and segment are concerned Appreciation of this fact is of great practical surgical importance, for it means that if the correct presentation of the abscess is assessed prior to operation for external drainage the pleura will always be found to be adherent over it. In certain situations, of course, such as deep interlobar presentation, the main pleura may be quite free from adhesions.

The primary abscess and the deeply situated abscess

The description given of the morbid anatomy applies to all lung abscesses except a few of the primary type, or of those, usually non-foetid, in which abscess formation is a relatively secondary event in a suppurative pneumonitis. In these cases the abscess cavity may be smaller and more deeply situated, and overlying pleural adhesions may be scantier.

(4) The significance of the lung slough

A lung slough is not always found, even in the acute foetid group, or the slough may be so small as to escape notice. It is important to note that when there is a slough in the abscess cavity spontaneous resolution cannot occur, furthermore, the loose dead tissue prevents drainage through the associated bronchi.

If the abscess is coughed up and empties quickly, in the absence of a slough, rapid healing can occur, the adjacent lung tissue soon obliterates the space and little or no permanent damage results.

(5) Chronic lung suppuration

If healing is delayed the walls become indurated, dense pleural thickening occurs, the surrounding lung becomes chronically inflamed and new satellite abscesses are formed, in addition, fresh "spill-over" abscesses appear in adjacent segments, in another lobe, or even in the other lung. In this way a condition of chronic lung suppuration is established which, if it heals at all, can only do so with permanent secondary fibrosis and bronchiectasis; often healing does not occur, and continued invalidism leads eventually to death. Metastatic pyaemic lesions, notably brain abscess, may also occur.

"Spill-over" abscesses

(6) Bacteriology

Spirochaetes and fusiform bacilli acting together, or various other anaerobic organisms, are usually responsible for acute foetid abscesses. The non-foetid group is more often due to streptococci, staphylococci, Friedlander's bacillus, or to mixtures of these or other organisms. It is often difficult to obtain satisfactory bacteriological studies from the sputum, but blood culture in certain of the specific abscesses will often be informative. The particular importance of this must be emphasized in the staphylococcal group, especially in children. An early blood culture may reveal the organism at a time when specific chemotherapy can be most effectively employed.

Bacteriological studies

5. CLINICAL PICTURE

The characteristic feature of a lung abscess is a febrile illness associated with the production of purulent sputum in quantities large enough to come from a cavity or cavities; the sputum may or may not be foul smelling. When a primary causal factor (such as an operation) is identified it will be found that there is usually a latent interval of 10–20 days before the chest illness develops The interval may be shorter, occasionally of only two or three days' duration. This latent interval may lead to failure of recognition of the relation between the primary cause and the abscess, especially if the patient has left hospital after an operation.

Latent interval

The onset of fever, cough and pleuritic pain in the chest may lead to a diagnosis of pneumonia until the raising of purulent sputum or the radiographic demonstration of the abscess points to the correct diagnosis. Classically, the abscess may rupture suddenly and a large quantity of pus, with blood, is coughed up at once; expectoration may steadily increase without sudden dramatic evacuation.

Subsidence may be rapid and uneventful and it is probable that many lung abscesses heal quickly and spontaneously without ever being diagnosed. More often there are intermissions and exacerbations of fever, illness and expectoration with gradual subsidence over several weeks, or continued illness, with or without remissions, until a stage of chronicity is reached. There is then steady deterioration of the general condition; the amount of expectoration increases and may reach 10–20 ounces a day. The patient's misery is extreme. New and acute abscesses may appear at other sites in the lungs and

at any time there is the risk of pleural infection proceeding to empyema or pyo-pneumothorax.

6. SPECIAL AIDS TO DIAGNOSIS

Radiography The most valuable aid to diagnosis is radiography. It is essential to remember that an abscess is often present even when a homogeneous opacity is seen; the most dangerous type, a blocked cavity, will certainly not show a fluid level because it is full of pus. Tomography is of help in some cases and bronchograms may assist in both localization and diagnosis.

Bronchoscopy Bronchoscopy is an invaluable means of excluding or identifying an intrabronchial lesion and of confirming the anatomical localization. It has a limited value in treatment.

7. DIFFERENTIAL DIAGNOSIS

The most important and dangerous confusion may arise in the case of an empyema which is being coughed up; this must always be borne in mind and aspiration or operation performed if there is any doubt. In the absence of a definite abscess cavity with a fluid level, the differentiation from a diffuse suppurative pneumonitis without frank abscess formation may also be difficult. Carcinoma must always be excluded; any abscess of doubtful origin in a patient over 45 years of age should always be suspect.

Diffuse suppurative pneumonitis

8. PROGNOSIS

The fact that many lung abscesses tend to heal with a conservative régime is apt to engender complacency. A lung abscess is always a serious condition, and carries a doubtful prognosis even when it appears to have almost resolved.

Relapse Relapse, either fatal or proceeding to chronicity, may occur even after many months, and not infrequently a cerebral abscess may appear when the chest has cleared completely.

9. INDICATIONS FOR SURGICAL INTERVENTION

(1) General considerations

The management of an abscess in the lung should differ but little from an abscess elsewhere in the body The general procedure in abscesses elsewhere is to encourage resolution, or maturation and spontaneous discharge, by rest, possibly by heat, by chemotherapy, and, if necessary, by measures to improve general health. If the abscess is slow to resolve or discharge it is incised, the treatment depending upon the pain and the degree of local or general disturbance. The more complex surgical approach to a lung abscess may justify a somewhat longer conservative régime, especially if improvement is occurring. It is, however, wrong to persist in delay if there is little or no improvement. The extra difficulty of access is balanced by the extra danger, to the patient, of the site of the abscess.

(2) Conservative measures

Conservative measures include rest in bed, chemotherapy, postural drainage, and possibly bronchoscopic aspiration, although this last is likely to be disappointing. Blood transfusion is often needed. Chemotherapy should include the sulphonamides as well as intramuscular injections of penicillin,

Chemotherapy

nd it is often advantageous to give direct intrabronchial instillation of enicillin; Métras and Lieutier (1947) have described special catheters which nable penicillin to be instilled into the affected segment. There is a slightly reater tendency for non-foetid abscesses to resolve without operation, and in he specific infections, especially staphylococcal abscess, the tendency to pontaneous resolution is so great that longer delay is both justified and ndicated. When a slough is present, as is most often the case in the foetid roup, resolution without operation is unlikely.

3) The time for operation

It is quite wrong to set an arbitrary time, such as 6 weeks, in which conservaive treatment is to be given before operation is contemplated. It may be quite ight to wait as long as this, or even longer, if steady improvement is occuring On the other hand, if serious illness continues, it may be wrong to delay peration more than a few days. In the acute foetid type in particular, operaion should be performed quickly as soon as it is clear that free drainage is not established. A large or increasing abscess with dense pleural reaction suggestng threatening intrapleural rupture is particularly dangerous. Moreover, early operation can lead to rapid cure with the minimum of residual lung drainage. If the abscess is allowed to become chronic (of more than 6–8 weeks' duration), the dangers of operation are increased and often a permanently damaged lung remains.

Acute foetid abscess

10. OPERATIVE TECHNIQUE

(1) Choice of operation

The best operation for acute lung abscess is external drainage. When the abscess has become chronic (more than 8 weeks old) the desirability of lobectomy or pneumonectomy arises. External drainage for chronic abscesses involves a considerable extra risk from secondary haemorrhage and cerebral abscess, and, moreover, a permanently damaged fibroid lung may render a persistent sinus and persistent sputum inevitable. Lobectomy or pneumonectomy by modern dissection technique is much more satisfactory for these cases as a primary measure; healing usually occurs by first intention and the mortality is much lower. In seriously ill patients it may be desirable to perform external drainage and later to do a secondary lobectomy.

Lobectomy and pneumonectomy

(2) External drainage

The first essential to external drainage is exact anatomical localization of the abscess from a study of good postero-anterior and lateral skiagrams, possibly aided by bronchoscopy. The "spot" method of localization advocated by Rabin (1941) is often helpful—1 millilitre of Lipiodol and 1 millilitre of methylene blue are injected into an intercostal space at the proposed site of drainage. Postero-anterior and lateral skiagrams will then demonstrate the relation of the "spot" to the abscess, and the position of the "spot" is confirmed by the dye at operation. By careful counting of the ribs and by actual measurement from the midline, in front or behind, a very precise localization should be achieved.

"Spot" method of localization

In this way it should be possible to perform one-stage drainage through the area of pleural adherence in over 90 per cent of cases. A two-stage operation

should be needed only when the pleural presentation is not costal, for example, interlobar or paravertebral presentation.

Anaesthesia

Local analgesia should be used; *an inhalation anaesthetic* carries the risk of flooding the lungs. The old "blunderbuss" method of resecting long segments of several ribs over an area in which the abscess is judged to be, is most undesirable. The risk of opening the pleura is great, and the large defect makes effective coughing more difficult. An incision is made down to the selected rib

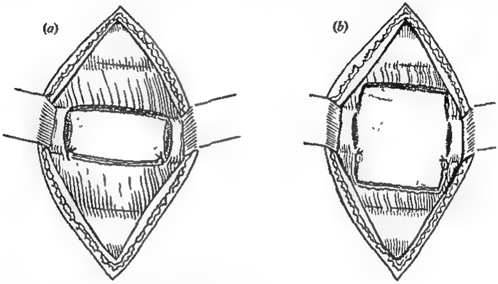
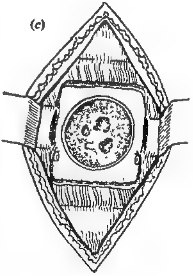


FIG. 88—(*a*), (*b*) and (*c*) Successive stages in the external drainage of a lung abscess



across the line of the rib and 4–5 centimetres of bone are resected subperiosteally (Fig. 88 (a)). The periosteum in the rib bed is divided, the intercostal vessels under-run at each end, and a segment of intercostal bundle above and below the space is excised (Fig 88 (b)). Palpation should then reveal whether soft, normal lung is uncovered, or whether rigid, indurated tissue is exposed; inspection will also show whether the lung is moving within the pleura. If the pleura appears free, the localization should be re-checked and, if necessary, a new site chosen or the incision extended appropriately. If it is decided that the presentation is not costal and a two-stage operation is necessary, a small gauze pack (slightly moistened with iodine) should be placed in the wound (outside the pleura, of course), a small metal marker laid on it and the wound closed by loose suture. Radiography will show the relation of the marker to the abscess, and the second stage can be performed 7–10 days later.

onfirmation
needling

If the pleura is adherent and the lung feels firm, the localization of the abscess is confirmed by direct needling. Pus, or pus and air, should be found

a very short distance (less than 1 centimetre) from the surface. The abscess can then be opened by simple incision, or by the actual cautery, although deliberate coagulation and then incision with diathermy is preferable if this method is available. Pus is sucked out, any lung slough is removed and the interior of the abscess is inspected and palpated so as to assess the exact direction in which the opening is to be enlarged; a definite portion of the roof is then excised so as to throw the abscess freely open (Fig. 88 (c)). It may be necessary to open adjacent loculi or other abscesses also. In removing the roof great care should be taken not to open the pleura. Occasionally, it may be necessary to resect a segment of one more rib, in which case the intervening intercostal bundle should be excised.

It is better not to use a drainage tube because of the risk of bleeding; the cavity and the surface wound should be lightly packed, either with dry gauze or with gauze soaked in zinc peroxide emulsion or in Vaseline. If desired, the cavity can be dusted with a penicillin-sulphonamide powder. A firm dressing is strapped in place; it is important to do this to ensure effective coughing. If the pleura is inadvertently opened, it should be closed by suture and the air removed by aspiration. *Light packing*

11. POST-OPERATIVE CARE

Dressing Unless the pack becomes very foul it need not be changed for 2–3 days; thereafter, daily change of the pack is needed; care must be taken not to pack so firmly as to distend the cavity. After 7–10 days the question will arise of replacing the pack by a *soft drainage tube. It is dangerous to use a tube while a* lung cavity of any size remains; the chief use of a tube is to maintain patency of the chest-wall wound, and it should project only a very short distance within the chest.

Chemotherapy should be continued and blood transfusion is often needed. The haemoglobin should be estimated weekly; iron, vitamins and a high-calorie high-protein diet should be given. The pleural cavity should be watched for the presence of fluid or air, and aspiration should be performed if needed.

Secondary haemorrhage If secondary haemorrhage occurs, the wound should be inspected in the operation theatre in a good light; a bleeding intercostal vessel should be under-run; hæmorrhage from the lung should be controlled by packing or diathermy.

12. RESULTS

The results of conservative management and of operation in a series of 238 cases of lung abscess (excluding those due to carcinoma) seen personally over a period of 5 years are shown in Table II.

TABLE II

RESULTS OF TREATMENT OF LUNG ABSCESS IN 238 CASES

No operation		*Operation*	
Total	139	Total	99
Died	19 (13%)	Died	23 (23%)
Cured	92	Cured	67
Non-resolution	28	Non-resolution	9
but add 99 (those in whom operation was needed)	127 (53% of total)		

It will be seen that conservative management failed in 146 cases (61 per cent); that is 28 cases of non-resolution, 19 patients who died, and 99 patients for whom operation was ultimately necessary.

Surgical results

The best results for surgical treatment of lung abscess are obtained in early drainage of acute abscesses. Neuhof and Touroff (1942) reported on 122 consecutive acute foetid pulmonary abscesses operated on with only 4 deaths. No other surgeon has, however, been able to report such good results. Sweet (1940) recorded a 26 per cent mortality for surgical treatment in 125 cases (not all acute). My own experience is closely comparable with that of Sweet's. Thus of 99 patients treated by operation between 1942 and 1946, 23 patients died (23 per cent). Of all my cases treated by operation, 47 died out of 176 (26·5 per cent). These figures cover abscesses at all stages from acute to late chronic and in great part reflect the poor condition of many chronic neglected cases in which the patients were operated on after failure of prolonged medical treatment. External drainage of a chronic lung abscess (more than 2 months old) involves considerable risk, and lobectomy, or in some cases pneumonectomy, is preferable. In this way rapid primary healing can usually be achieved, providing that the hilar structures are dissected and ligated; a tourniquet technique will lead to a high incidence of fistula and empyema and should not be used.

Radical resection

There were only two deaths in a series of 28 lobectomies, with not one in the last 17; in 16 pneumonectomies there were 4 deaths. Thus out of 44 chronic abscesses treated by radical resection there were 6 deaths (a mortality rate of 14 per cent). In most of these cases healing occurred by primary intention, and in addition to the lower mortality, and the extirpation of a permanently damaged lobe, the patient was spared the many weeks or months of daily dressings usually needed when external drainage is used in a chronic case

This high mortality of the surgical treatment of lung abscess, although it occurs in those cases in which medical treatment has failed, does emphasize that lung abscess is always a serious condition.

REFERENCES

Brock, R. C (1942). *Guy's Hosp. Rep.*, **91**, 111.
— (1943) *Ibid.*, 92, 26, 82, 123.
— (1944) *Ibid.*, 93, 90
— (1945). *Ibid*, 94, 115.
— (1946) *Anatomy of the Bronchial Tree. With Special Reference to the Surgery of Lung Abscess.* London; Oxford University Press.
— (1947). *Guy's Hosp. Rep.*, 96, 140.
Foster-Carter, A. F. (1942) *Brit. J. Tuberc* , 36, 19.
Métras, H., and Lieutier, J. (1947). *Thorax*, 2, 196.
Neuhof, H., and Touroff, A. S. W. (1942). *J. thorac. Surg.*, **12**, 98.
Rabin, C. B. (1941). *J. thorac. Surg.*, 10, 662.
Sweet, R. H., (1940) *Surg. Gynec Obstet* , 70, 1011.
[References to other titles are given under Pulmonary Abscess in the Index Volume]

PULMONARY TUBERCULOSIS

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1. GENERAL CONSIDERATIONS

281.] The chief aim of surgical treatment in this disease is the control of the lesion which has reached the stage of cavitation.

Cavity formation

Cavities occur as a result of the rupture into the bronchial tree of a tuberculous abscess, the contents of which are either coughed up or removed by the ciliary action of the mucosa.

Cause of persistence of cavity

As a result of the rupture of the abscess into the bronchial tree, the juxta-cavitary portion of the bronchus (or bronchi, for most commonly there are multiple bronchial openings into the cavity) *becomes the seat of a tuberculous* bronchitis, the whole mucosa being replaced by granulation tissue; if the bronchus is examined more proximally, *submucosal tuberculous infiltration* will be found, giving place more proximally still to a submucosal hyperaemia. These changes cause narrowing of the lumen of the bronchus which is such that during the latter part of the expiratory phase the bronchial lumen is closed; in other words, there is an expiratory stenosis. Resulting from the

Expiratory stenosis

expiratory stenosis, air which enters the cavity during inspiration cannot be expelled completely, but is retained within the cavity, and during the period when the bronchus is closed the air is under a mean pressure which is greater than atmospheric pressure. Thus, all tuberculous cavities which persist are

Tension within the cavity

tension cavities in the early stages of their evolution and before the complicating factors of attachment to the chest wall arise. The degree of tension within the cavity will depend upon the severity of the stenosis and the elasticity of the cavity walls. If the degree of stenosis increases and the elasticity of the walls remains the same, the cavity may increase in size considerably, as sometimes happens when a pneumothorax is induced, when it is called a distension cavity.

Distension cavity

The increased tension within the cavity is not only the cause of its persistence as a cavity, but is also the main cause of the persistence of the tuberculous process. As the result of positive pressure within the cavity, the blood supply of its wall is embarrassed, because blood will flow more easily through the adjacent capillaries which are not subjected to the positive pressure. In this way the local defence mechanism is hampered. Evidence of this can be obtained by examining the cavity walls in cases submitted to external drainage after the method of Monaldi. Examination of the walls through an endoscope at the time of drainage shows them to be identical with those classically seen in post-mortem specimens—inert grey walls with caseous material attached to them; after 2 weeks' treatment by negative pressure aspiration, the walls have become smooth and glistening, but pale. Inspection after a further 2 weeks' treatment shows the walls to be smooth and red—one can almost see the capillaries. It is significant, too, that at this time tubercle bacilli disappear from the discharge, and from the sputum if the cavity is the only lesion. *Persistence of the disease*

The conclusion to be drawn from the above observations is that all tuberculous cavities should, if possible, be closed, even though the patient has no symptoms of general intoxication; this should be done not only as a public health precaution in order to eliminate the dissemination of the tubercle bacilli, but also for solution of the problem of arrest of the disease in the individual affected.

As with persistence of the cavity, the condition of the bronchus provides the clue to its closure.

There is a great deal of accumulated evidence to show that the prerequisite of cavity closure is closure of the draining bronchus, or more correctly, bronchi. This was first postulated by Coryllos (Coryllos and Ornstein, 1938), and is now accepted by the majority of workers. *Cavity closure*

It is true that in a minority of cases, healing of the tuberculous process may occur not only with a patent bronchus, but also with a patent cavity, the diseased area being converted into fibrous tissue. It is also important to appreciate that whatever active measures are adopted to control the disease it is, in the final analysis, the patient's own resistance which establishes the cure.

Principles of relaxation

Accepting the thesis that cavity closure results from bronchial closure, it will be seen that, if cavity drainage and lung resection are excluded, the same principles underly all forms of treatment from rest in bed to thoracoplasty.

The principles are those of passive and active relaxation.

(*a*) *Passive relaxation*

Passive relaxation means the diminution of the inspiratory tug on the bronchial walls. During inspiration, as a result of the direct pull of the chest wall transmitted through the lung to the walls of the bronchi, their lumina increase in size. The greater the inspiratory excursion, the greater the increase in the lumen. When a patient is at complete rest in bed, his oxygen requirements are decreased and consequently so also are the respiratory excursions of the thoracic wall. If the stenosis of the draining bronchi is such as to maintain bronchial closure during the whole respiratory phase, then the cavity will *Rest in bed*

close. The stenosis at first is only functional, and it is necessary to keep the patient at rest for a sufficient length of time to convert it into a permanent stenosis by cicatrization of the bronchial wall. Complete rest in bed should be stressed; 20 hours' rest out of the 24 defeats the object in that during the 4 hours' exercise the bronchus reopens and will remain open. A minimum of 6 weeks, but preferably 3 months, rest in bed should be carried out if it is apparent that the cavity has disappeared. Evidence of the latter will, in the great majority of cases, be obtained in less than 6 weeks.

The majority of cavities, 70–80 per cent, will not close by rest in bed, passive relaxation not being sufficient.

(*b*) *Active relaxation*

Artificial pneumothorax

Active relaxation occurs in all the procedures which bring about actual decrease in the lung volume. The best method of achieving relaxation when the lung is completely free from the chest wall is by an artificial pneumothorax. In this way, the relaxation is concentric and produces a further decrease in the lumen of the bronchus, and on this active relaxation depends the closure of the bronchus and of the cavity. In an artificial pneumothorax any attachment of the lung to the chest wall may not only prevent relaxation of the bronchus, but may also allow of inspiratory increase in its lumen through the chest wall attachment. Artificial pneumothorax, when perfect, produces closure of cavities in about 95 per cent of cases, and all other methods used should, so far as is possible, try to reproduce the same condition, that of concentric relaxation.

2. CLINICAL FEATURES

Acute exudative disease

Contra-indications to operation

The clinical features of the disease are well known, and detailed discussion would be out of place. There are, however, certain basic features of importance to be considered when a case is submitted for surgical treatment. Acute exudative disease contra-indicates any form of relaxation therapy, even artificial pneumothorax, and generally speaking, exudative lesions contra-indicate surgical intervention. The chief reason underlying this ban is not to be found in any mechanical conditions associated with this phase of the disease, but in the fact that the exudative phase is an index of the progression of the disease, for it indicates that the patient's resistance is at its lowest. It is true that exudative lesions coexist with fibrotic lesions in the majority of cases, and that a rough estimate of the predominance of one or the other can be obtained from the skiagrams of the chest; for practical purposes, however, the patient should be assessed on clinical grounds in association with the skiagram and ancillary evidence.

Grouping of patients

Patients are grouped clinically according to whether their condition is:

is low.

(2) Relapsing chronic. This group comprises the majority of cases. These patients run a course similar to those in the stable chronic group except in that from time to time they have periods of toxaemia, with pyrexia, usually some loss of weight, a rise in the sedimentation rate, increase in focal

symptoms of cough and expectoration and, not infrequently, some extension of their disease radiographically. After a while the symptoms subside and the condition improves, but rarely to the level obtaining before the relapse.

(3) Slipping chronic. As the term suggests, patients in this group have a steady, though slow, downhill course; they are toxic, as shown by the continued pyrexia, loss of weight, high sedimentation rate and the steady extension of their disease. Although these patients are amenable to treatment, considerable experience is needed by the practitioner undertaking the treatment and considerable fortitude and co-operation are required on the part of the patient. As would be expected, however, the mortality rate in this group is high. *Mortality rate*

(4) Hopeless cases differ from the slipping chronic group only in the rate of the downhill course.

The important conclusion to be drawn is that, when possible, operative intervention should be carried out only when the patient's resistance is at its peak. Any suggestion that the patient is approaching, or in the middle of, a relapse is an indication for a conservative policy, except in the third group, when a policy of delay leads only to further permanent deterioration. Too much stress cannot be laid on the value of a complete review of the patient's history and course of the disease with all the available data, even though the history is of many years' duration, before active intervention is embarked upon. *Conservative policy*

3. DIAGNOSIS

Methods of investigation

(*a*) *Radiography*

Radiographic control is essential, not only during the pre-operative and operative periods, but also in the post-operative periods.

In the main, antero-posterior skiagrams suffice, but before treatment is undertaken, at least one good lateral skiagram should be taken in order accurately to localize the cavities.

Tomography.—Tomographs are, perhaps, more valuable in this disease than in any of the other chest conditions for the identification of unsuspected cavities, especially after thoracoplasty has been performed; often, unsuspected infiltrative lesions are recognized in this way. To be of the greatest value, cuts of 0 5 centimetre should be made of the whole area. *Identification of cavities*

Apart from the evidence of cavitation, radiography will give some idea of the degree of fibrosis and shrinkage of the lesion, as evinced by the degree of mediastinal displacement and the approximation of the ribs on the affected side, though the former commonly results from atelectasis of the segment or lobe. *Degree of fibrosis*

(*b*) *Bronchoscopy*

In Great Britain, bronchoscopy is not practised as extensively in this condition as in other chest diseases, or as much as it is in the United States of America, although there is a tendency at the moment to increase its use. It is essential for establishing the presence of a tuberculous tracheo-bronchitis, and should be undertaken if there is the slightest suspicion of its presence. It is, of course, essential in cases in which pulmonary resection is contemplated, in order to determine whether or not the projected line of bronchial

Contra-indications

resection is relatively healthy. It is unwise to undertake bronchoscopy when ulcerative lesions of the larynx are present, because severe oedema of the glottis may result.

(c) *Blood sedimentation rate*

The value of the sedimentation rate lies not so much in the actual readings as in their [illegible] but a high r[illegible] at weekly [illegible] intervals show that the rate *remains* at the same level; if, however, the rate, having been low, suddenly goes up, it is much wiser to withhold surgery, despite the absence of any *obvious clinical* or radiological change in the patient's condition. In many cases, further observation for two or three months will show that there has been an extension of the disease in either the lungs or some extrapulmonary area.

A dropping sedimentation rate is a valuable indication for a waiting policy until the rate is stabilized, when it can be concluded that the maximal improvement has been achieved.

(d) *Spirometry*

Assessment of the patient's respiratory efficiency rests mainly on clinical evidence, but the patient's vital capacity should be assessed by spirometric readings. In cases in which bilateral disease is present, bronchospirometric readings should be carried out, with assessment of the gas exchanges in each lung respectively. In this way it may sometimes be found that the patient's respiratory function depends almost wholly upon the side on which operation is contemplated.

4. TREATMENT

Cavity closure, by the simplest method by which it can be achieved, is the aim of treatment.

Choice of operation

Of the relaxation methods, the following are those most commonly used: diaphragmatic paralysis, extrapleural artificial pneumothorax and thoracoplasty.

The methods not using the principle of relaxation are cavity drainage and lung resection.

Relaxation procedures are far more commonly used than the other methods, and at the present time afford a much better outlook for the patient, both with regard to the arrest of the disease and to the mortality of operative procedures.

5. DIAPHRAGMATIC PARALYSIS

Diaphragmatic paralysis is produced by interruption of the phrenic nerve, and may be temporary or permanent; temporary by crushing, or permanent by evulsion of, the nerve, the latter nowadays rarely being practised (Fig. 89).

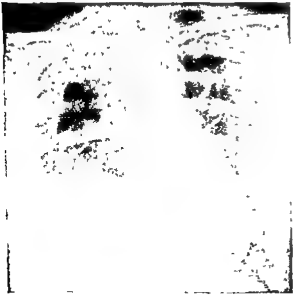
Disadvantages of indiscriminate use

This is the simplest intervention that is carried out, and its very simplicity leads to its abuse. Wisely used, it is of great value; used indiscriminately it has serious disadvantages. These are: (1) the fact that it has been performed gives a false sense of security to the patient and not infrequently to his medical

attendant, despite the fact that the cavity has not been closed; (2) that having failed, and thoracoplasty becoming necessary, the risk of collapse of the lung base during the major operation is between two and three times as great; and (3) even when temporary paralysis is aimed at, in about 3 per cent of cases the paralysis remains permanent—a serious consideration if a complete thoracoplasty becomes necessary, as then the patient depends almost solely upon the movements of the diaphragm to aerate the normal lung tissue remaining.

In consequence, the cases submitted to diaphragmatic paralysis should be carefully chosen and operated on only when there is a real expectation of a satisfactory result, and never as a pious hope.

(*a*)



(*b*)

FIG 89 —Skiagrams show right apical cavity with some surrounding infiltration: (*a*) before phrenic crush; (*b*) after phrenic crush. Note high rise of diaphragm and closure of cavity.

(1) Indications for operation

The following groups of cases can be expected to react favourably.

(a) Those cases with apical cavities not more than 2 centimetres in diameter, with relatively little surrounding infiltration, and with disease not of long standing.

(b) Cases in which there is an artificial pneumothorax, and the apex is attached to the plural dome and to the diaphragm but lateral adhesions are absent In this type of case, cavity closure can be expected after about 90 per cent of operations.

(c) Those with cavities in the lower lobe, both in the apical segments and in the basal segments. It is true that satisfactory results can be expected in only

a small percentage of cases. This, however, applies to the bulk of relaxation procedures, with the exception of a perfect artificial pneumothorax, and in consequence a trial of this simple procedure is justifiable. Diaphragmatic paralysis in this group can and should be supplemented by the introduction of air into the peritoneum. This increases the degree of rise of the paralysed hemidiaphragm through two or three rib spaces, thereby increasing the value of the procedure. A pneumoperitoneum, however, does tend to increase the length of time the paralysis lasts and consequently should be used with discretion. Experience suggests one added value of pneumoperitoneum in cases with a paralysed diaphragm, in that it probably prevents the paradoxical movements of the diaphragm and, in consequence, is a valuable added procedure when thoracoplasty is to be undertaken.

Pneumoperitoneum

(2) Operation

Incision

The operation is carried out under local anaesthesia. An incision 1½ inches long is made parallel to, and 1–1½ inches above, the clavicle. The fibres of platysma are retracted, and the posterior margin of the sternomastoid is defined and drawn inwards. Retraction and elevation of the tissues puts the fascial planes under tension, and blunt dissection, by separation of the blades of a pair of scissors or curved haemostatic forceps, carrying the dissection at right angles to the skin surface, will expose the fascia covering the scalenus anterior. This fascia should be preserved intact; tearing it possibly leads to elevation of the nerve on the retractor as with the ureter on the peritoneum. The nerve crosses from the outer to the inner margin of the scalenus anterior muscle in the rough rhomboid formed by the internal jugular vein internally, the brachial plexus externally, and the upper and lower limits of the area of dissection. The nerve may cross the scalenus at a high or low level, and only when it has been clearly identified should it be picked up through the intact fascia and crushed; if there is any doubt it is better to leave the operation unfinished and return to it a few days later. Preservation of the integrity of the fascia is important especially if a re-crushing of the nerve becomes necessary at a later date; if the fascia has been opened for the crushing, the tissues will be found to be adherent, often densely, over the nerve; when it has been left intact, the second operation can often be conducted with the same ease as the first intervention.

Identification of nerve

Evulsion

If an evulsion of the nerve is deemed to be necessary, the nerve is grasped with artery forceps and divided, then cleaned of its fascial attachments and a slow steady pull is exerted—the longer this takes the better—until the nerve breaks. Except in the rarest of circumstances, evulsion should not be practised for a parenchymal lesion.

(a) Complications

The complications of the operation should be rare, and are in the main due to faulty technique and lack of proper identification of the nerve. The vagus nerve, the sympathetic trunk and parts of the brachial plexus have all been mistaken, quite unjustifiably, for the phrenic nerve. There is no doubt whatsoever when the nerve itself is exposed. The internal jugular vein has been opened inadvertently; there should be no serious difficulty in controlling the resulting haemorrhage—it will be necessary, of course, to enlarge the incision a little. This misfortune occurs when there has been a pre-existing adenitis

Internal jugular vein

or when the operation is performed after a previous intervention or after thoracoplasty.

(*b*) *Scalenotomy*

Section of the scaleni (anterior, medius and posterior) has been advocated as an adjunct to diaphragmatic paralysis. The results scarcely warrant the more extended operation, which is done through a longer incision placed nearer the clavicle.

6. EXTRAPLEURAL ARTIFICIAL PNEUMOTHORAX

(1) Advantages and disadvantages

The outstanding advantage of this operation is that it does not destroy the integrity of the chest, which means that first, there is no resulting external deformity and, secondly, there is little or no paradoxical movement of the lung. The former is merely of aesthetic value, doubtless of some importance in dealing with young females; these patients, however, will agree readily to thoracoplasty with its attendant deformity if they are taken completely into the confidence of the medical attendant and the whole situation is clearly explained to them. *Aesthetic value*

The presence of paradoxical lung movement is of considerable importance in this disease apart altogether from the respiratory embarrassment it entails. In the first place, the abnormal degree of movement of the area of lung which is the seat of disease leads to a greatly increased flow of toxin-laden lymph into the circulation—the chief cause of the severe post-operative reaction. Secondly, it leads to aspiration phenomena in other areas of the lung because, during the inspiratory phase, secretions are sucked from the area subject to paradox, the whole of which is deflated during inspiration. These latter observations explain why thoracoplasty is the most serious of the relaxation procedures. *Effects of paradoxical movements of the lung*

The other advantage of extrapleural artificial pneumothorax is that it is not an irreversible method of relaxation to the same extent as is thoracoplasty. *Not irreversible*

The disadvantages of the operation lie first, in that it is not applicable to all cases and, secondly, in the high complication rate.

Choice of case.—The operation is best suited to those cases in which:

(1) A satisfactory intrapleural artificial pneumothorax cannot be obtained.

(2) The disease is recent, that is, of not more than 6 months' duration.

(3) The disease is almost wholly unilateral, affecting the apex only, and cavitated.

(4) The cavity or cavities are not more than 2–3 centimetres in diameter and are not subpleurally placed.

(2) Operation

(i) *Sedation.*—Pre-operative sedation consists in $\frac{1}{3}$ grain Omnopon and $\frac{1}{150}$ grain hyoscine given intramuscularly.

(ii) *Anaesthesia.*—The operation is usually done under local anaesthesia, using 1 in 2,000 amethocaine, locally infiltrating the line of the incision and performing a posterior intercostal nerve block of the second to the seventh or eighth dorsal nerves. When the mediastinum is being exposed it may be necessary to inject the vagus nerve to prevent the patient's coughing when the mediastinum is touched. This can be done quite satisfactorily with a long *Vagus nerve block*

(12-centimetre) needle. Some surgeons prefer general anaesthesia for the operation so as to avoid the coughing; this seems to be unnecessary.

(*a*) *Technique*

(i) *Incision.*—The incision is made between the vertebral border of the scapula and the spine, nearer the latter than the former, so as to cover the fifth and sixth ribs, and about 6 inches long. This incision is placed so as to form part of a thoracoplasty incision should that operation be indicated later.

(ii) *Section of rib.*—As long a portion as possible (a minimum of 3½ inches) of the fifth, occasionally of the sixth, rib is resected. The periosteum is carefully preserved to ensure ease of closure, as the intact periosteum will withstand very considerable tension. The periosteal bed is now incised and the extrapleural tissue is exposed. In this position, most frequently, fibres of the internal intercostal muscles will be found which need sharp division.

(iii) *Stripping of the pleura.*—When the pleura is exposed, it is stripped away from the chest wall; a pair of closed long-handled curved scissors used as a blunt knife is the best instrument to use, supplemented by gauze pressure when things are going easily. It is wise to liberate the pleura below the lower lip of the wound at an early stage, as this is more difficult to do when the apex has been released.

A small self-retaining retractor is now introduced to give better access. Stripping of the pleura is carried out under direct vision over the dome and down on the mediastinum on the right side over the vena azygos major, on the left over the aortic arch to the lung root, and anteriorly, laterally and posteriorly to the level of the eighth rib posteriorly. An extensive stripping is essential, to ensure closure of the cavity and the easy maintenance of the pneumothorax.

Adherent pleura

If, as it is being stripped, the pleura is found to be firmly adherent to the chest wall, it is wiser to abandon the operation, for the adherence indicates that the lung also is seriously adherent at this site, and by this time the lung is receiving a blood supply from the intercostal vessels. Section of these vessels deprives the lung of its blood supply and in consequence there is a quiet necrosis and extension of the disease to the extrapleural space. This is probably the main cause of tuberculous infection of the space; it is also a contributory cause of post-operative haemorrhage. A sound canon is to abstain from sharp dissection in performing the stripping of the pleura.

Extension of disease to extrapleural space

Case 1 Went to
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(iv) *Wound closure.*—The wound is sewn so as to produce an airtight closure. The periosteal edges are sutured, commencing the suture from the posterior and anterior ends of the wound with two separate continuous

sutures. The first part of the sutures surrounds the cut end of the rib. The muscles and skin are approximated.

(*b*) *Operative complications*

Reference has already been made to intractable cough and to the method adopted to combat it. Some operators advocate blocking the vagus nerve in the neck as a routine measure before operation. The frequency of the complication hardly seems to warrant the regular use of this procedure.

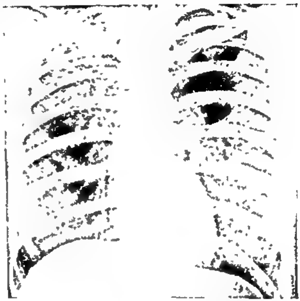

FIG. 90. *Case* 1.—Skiagram shows cavity at right apex with a great deal of surrounding infiltration. Some infiltration of middle zone of left lung

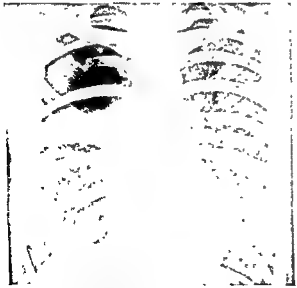

FIG. 91. *Case* 1—Skiagram shows extrapleural artificial pneumothorax.

(i) *Perforation of the pleura*—In some patients the pleura is of tissue-paper thinness and very great care is necessary if perforation is to be avoided. Perforation adds considerably to the difficulty of the operation and to the discomfort of the patient, as an intrapleural pneumothorax is established. In these circumstances the pleura balloons into the wound and the line of cleavage is difficult to visualize. The operation should be carried out as usual, however, except in the presence of a contralateral artificial pneumothorax, when it may be necessary to use a general anaesthetic and controlled respiration. *Controlled respiration* The hole in the pleura should be closed on completion of the stripping and air should be aspirated from the pleural cavity. Not infrequently these patients develop a post-operative intrapleural effusion which will need aspirating.

(ii) *Perforation of the lung or cavity.*—Perforation of the cavity has been described more commonly with the old operation of plombage. It should not

occur in the modern operation if the indications are adhered to and the operation is carried out under vision. If, unfortunately, this complication should occur, the wound should be enlarged by further rib resection to give adequate and easy access and sufficient mobilization of the surrounding area should be effected so that suture can be performed without tension. The cavity should be cleaned out thoroughly, the margins of the perforation excised and then sutured with catgut, burying the first layer with two further layers of catgut sutures. The pneumothorax can then be completed. It is probably safer, however, to abandon the extrapleural artificial pneumothorax by reinflating the lung and either to proceed to an upper thoracoplasty at once if the patient's condition will allow or to postpone this operation for 14 days. In the latter case, aspiration of the extrapleural space is essential in order that the lung may become attached to the chest wall without delay.

Enlargement of wound

(c) *Post-operative complications: immediate*

(i) *Haemorrhage.*—This is the commonest immediate post-operative complication. Most commonly it occurs about 48 hours after operation and usually follows some added stress, such as coughing, vomiting or straining at stool. Its origin is probably venous, and it results from the dislodging of a terminal clot consequent upon the raised intravenous pressure.

It may be alarming in its extent, and fatalities from this cause have occurred, though rarely. Commonly, the extrapleural space fills to a variable extent with blood, and air is pushed out of the extrapleural space into the intramuscular and subcutaneous planes. The pulse becomes rapid and small and, not infrequently, there is dyspnoea with a complaint of tightness in the chest.

Treatment

Treatment consists in replacement into the circulation of the blood which has been lost, and aspiration of the blood from the extrapleural space. Not infrequently, aspiration of the space is unsatisfactory owing to clotting. In these circumstances, the patient should be returned to the theatre, the wound should be reopened under general anaesthesia and the clot removed under vision; the bleeding-point is seldom seen at operation. Aspiration through a thoracoscopic cannula is rarely satisfactory when clotting has occurred Failure to remove the clot leads either to re-expansion of the lung or to sepsis.

Sepsis

[illegible] without haemor-
[illegible] ases. When slight,
[illegible] that refills should
be carried out frequently.

(iii) *Sepsis.*—Pyogenic infection is an index of faulty technique and should not occur. With chemotherapy it should not present a difficult problem.

(d) *Post-operative complications: late*

Tuberculous infection of the extrapleural space.—Tuberculous infection, when it occurs, results from an extension of the disease from the lung to the extrapleural space. This occurs on an average about 3 months after the operation. It is a rare complication if the indications for the operation are strictly followed. The predisposing causes have already been indicated.

Treatment

The basis of treatment depends upon the acceptance of the presence of a subclinical broncho-extrapleural fistula. Repeated aspiration, leaving the extrapleural pressure highly negative in the majority of cases, leads to closure of the fistula. The change in the character of the aspirated fluid will soon give

an indication that closure has occurred. In successful cases, the fluid changes from frank pus to a sero-sanguineous effusion in 2–3 weeks. The pressures should now be left at a mean zero. The fluid will clear up spontaneously and the artificial pneumothorax can be maintained; positive pressures should not be used for a further 4 or 6 weeks.

(e) *Post-operative care*

Post-operative care should be carried out under frequent radiological control. Fluid collects in the extrapleural space in all cases and is not of any consequence unless it is excessive. The diametrically opposed practices of keeping the space dry by frequent aspirations, and refraining from aspirations as far as possible, are both practised; whichever method is used the space becomes dry in about 1 month. Needling carries the obvious risk of introducing infection either by using imperfectly sterilized instruments or by piercing the lung edge with the needle. The conservative method reduces these risks to a minimum, and is the safer procedure when there is no indication that haemorrhage has occurred. *Fluid*

Refills with air should be carried out as frequently as is necessary. This will vary in the early stages from daily refills to two or three times weekly, the rate of air absorption varying in different patients. The extrapleural pressure should be maintained at a mean zero for the first 2–3 weeks and then taken to +4 and then up to +10 or +12. If there is evidence of re-expansion, pressures of +20 are quite justifiable. *Refills*

The nursing staff should be instructed to report immediately a sudden increase in pulse rate, any degree of surgical emphysema, or the onset of dyspnoea, these being the outstanding clinical manifestations of the complications. *Reporting of complications*

(3) Combined extrapleural and intrapleural artificial pneumothorax

This is an operation which has been widely used in the past. It entails stripping the adherent apex and cutting the pleura at the margin of its attachment so that the apex lies free in communication with a pre-existing intrapleural pneumothorax. The incidence of tuberculous infection in this operation is in the region of 30 per cent, which in itself prohibits the operation. *Tuberculous infection*

RESULTS

Cases operated on at Brompton Hospital and followed up between 1938 *and* 1945 (Roberts, 1935)

Extrapleural cases (100)	
Early mortality – –	– 14 per cent
Late mortality – –	– 29 per cent
Combined extrapleural and intrapleural cases (28)	
Early mortality – –	– 21 per cent
Late mortality – –	– [illegible] per cent

7. THORACOPLASTY

(1) Definition

The term thoracoplasty will be used to connote removal of portions of the ribs with apicolysis (Sembs, 1936), and the term lateral thoracoplasty to mean removal of portions of the ribs only. Partial thoracoplasty indicates that a varying number of ribs—up to seven—have been partially resected.

(2) Indications for operation

There is no easy way of detailing the selection of patients for the operation The following considerations, however, act as a guide. (1) The resistance of the patient to his disease. (2) The extent and site of the disease. (3) The likelihood of the patient being reasonably fit after the operation.

Fibrosis

The patient's resistance can be gauged when placing him in one of the three main categories, stable chronic, relapsing chronic or slipping chronic. Evidence of retraction of the part or whole of the hemithorax affected is an index of fibrosis. The ideal case in this respect is the stable chronic, and next the relapsing chronic. In the latter, if the patient is operated on only during the stable phase, the risks are reduced to a minimum. Operation on the slipping chronic should be embarked on only when the operator has considerable experience of the technique of the operation, of the behaviour of the disease and of the choice of cases. The extent of the disease and the prospect of the patient being left with sufficient respiratory function are intimately associated. An operation which is so extensive as to leave the patient a respiratory cripple should not be undertaken. This consideration applies only when the disease is bilateral.

The site of the cavitation, however, has a serious bearing on the prospect of success. Cavities in the apex of the upper and lower lobes can be successfully

FIG. 92 *Case* 2—Skiagram shows cavitation at right apex and infiltration of middle zone of left lung.

FIG. 93 *Case* 2—Skiagram after a right artificial pneumothorax had been induced, but had subsequently been abandoned because it was contra-selective

treated by thoracoplasty, but cavities occurring in the basal segments of the lower lobe offer little prospect of successful closure.

Ideal indications

The ideal indications for operation are found in the stable chronic case in which the disease is strictly unilateral, and preferably apical. For many cases which do not fall into this category there is no

prospect other than that offered by thoracoplasty. Difficulties in making a decision will arise in this group. The only safe procedure when a decision to operate has been arrived at in the latter group is to limit each stage of the operation so that only a small portion of the thoracic cage is mobilized each time.

Case 2

operation.

Extrapulmonary lesions

Larynx

The presence of extrapulmonary lesions should be considered before a final decision is made. Laryngeal tuberculosis is an indication rather than a contra-indication and only constitutes the latter when it is advanced, and pain is such as to interfere with proper feeding.

Intestine

Intestinal tuberculosis when fully established contra-indicates operation, as it is progressive, even though the pulmonary lesion is controlled. Diarrhoea which is intermittent only, and which most probably indicates tuberculous enteritis, does not necessarily contra-indicate thoracoplasty if the operation can be carried out during a quiescent phase.

FIG 94. *Case 2.*—Skiagram shows cavity, revealed in Fig 92, closed

Genito-urinary tract

Genito-urinary disease does not necessarily contra-indicate operation. Epididymitis in the male will often improve when the pulmonary lesion is controlled. Overt renal tuberculosis should be assessed on its merits; if strictly unilateral and amenable to surgery, it should not contra-indicate thoracoplasty.

Diabetes

Diabetes mellitus, if it can be controlled, is not a contra-indication. In fact, arrest of the pulmonary lesion will often lead to easier control of the diabetes.

Cardiovascular lesions must be carefully assessed.

Age

Age does not necessarily contra-indicate operation. At the extremes of under 15 and over 50 years, however, there should be urgent reasons to justify the risk of thoracoplasty; in the former group owing to the degree of deformity following the operation, although this has been overstressed, and

in the latter group, because the hazards of the operation are greater after the age of 50 years.

(3) Pre-operative care

Explanation to patient

All cases should be observed for at least a fortnight even when a complete follow-up of the patient is to hand. This period allows the patient to become friendly with his nurses and medical attendants The whole course of treatment should be explained to the patient in detail: the need for staging the operation, for the pre-operative and post-operative exercises, and for post-operative rest in bed. Only in this way will the patient give his full co-operation The bulk of the pre-operative period should be spent in bed, though all cases, except the slipping chronic case, should be allowed up for a little time each day.

(a) *Pre-operative exercises*

Respiratory rehabilitation

Full inspiratory exercises before the lung lesion has been properly controlled are to be condemned since they may lead to further reactivation. Diaphragmatic and abdominal exercises are, however, invaluable as a pre-operative measure, especially in females, and especially the expiratory phase of the exercises.

Postural and arm exercises should be carried out before operation, so that the patient should be aware of what is expected of him later.

Oxygen

The patient should be trained in the use of an oxygen mask, and the possible need for its use after operation should be explained to him This eliminates the panic some patients have at the mere thought of the necessity for oxygen, and also the first discomforts of using a mask.

Cough

By the time thoracoplasty is mooted most patients have discovered the easiest way to raise their sputum. Posture may play a part in this, and the patient should be encouraged to clear his bronchi of all secretion possible before operation.

(b) *Pre-operative sedation*

One hour before operation a hypodermic injection is given of $\frac{1}{3}$ grain Omnopon and $\frac{1}{150}$ grain hyoscine. If it is deemed to be necessary, this can be reinforced by an intravenous injection of a further $\frac{1}{3}$ grain Omnopon when the patient comes to the theatre.

(c) *Anaesthesia*

Local anaesthesia—a combination of local infiltration of the line of the incision, a brachial plexus block and a paravertebral block—is the anaesthesia of choice.

(4) Operation

(a) *Position of patient*

The patient is placed on the sound side with a soft, but firm, pad under the chest. Some form of chest support is necessary which does not come above the level of the third rib anteriorly in order to facilitate removal of the anterior ends of the second and first ribs. Too bulky a rest interferes with proper elevation of the scapula. The pelvis is also supported by a rest and a restraining strap is placed over the thighs. The arm is allowed to hang over the side of the table but is supported by a nurse.

(*b*) *Incision*

The incision is L-shaped, the vertical limb extending from the upper border of the scapula down to the level of about the eighth rib posteriorly and lying nearer the spine than the vertebral border of the scapula. At the lower end the incision curves forward and extends transversely to about the posterior axillary line (Fig. 95).

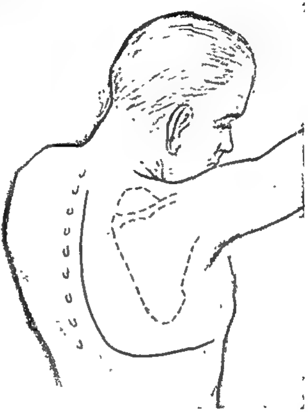

FIG 95.—Incision for thoracoplasty.

Exposure of the ribs

The skin edges are draped with towels and the muscle planes divided. The scapula is now elevated and dissected away from the chest by sharp dissection. This is usually done with the diathermy point and should be carried out under strict visual control and with meticulous haemostasis. The upper border of serratus anterior is visualized and separated from the axillary fascia by blunt dissection before its detachment from the chest wall is commenced. The digitations attached to the first, second and third ribs are dissected off completely and the axillary contents displaced away from the chest wall until the margin of the pectoralis minor is seen, the outer fibres of which are also detached. The muscular edges of the wound and that portion of the chest wall not subject to intervention are covered with moist wool packs.

The serratus posterior superior is dissected off the chest wall and removed. This exposes the posterior margin of the scalenus posterior which is detached from the second rib, the redundant portion being excised. A portion of the scalenus medius is detached from the upper surface of the first rib by pushing a pair of forceps through its substance close to the surface of the rib, on to the finger which guards the first thoracic nerve as it comes up over the inner margin of the rib (Fig. 96).

(*c*) *Rib resection*

What may be called the standard operation entails resection of parts of the third and second ribs and the whole of the first rib. The extent of rib removed will depend upon the case, as has been indicated; the local condition of the apex will also influence the decision. If the apex is soft and mobile,

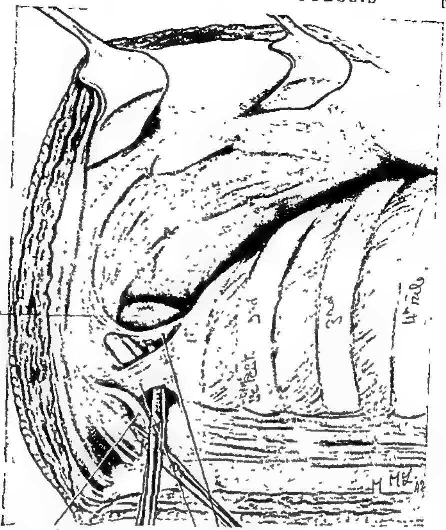

FIG 96.—Figure shows chest wall on the right side after detachment of serratus anterior and serratus posterior superior The scalenus posterior has been detached, and the forceps have been placed through the fibres of the scalenus medius at the level of its attachment to the upper surface of the first rib.

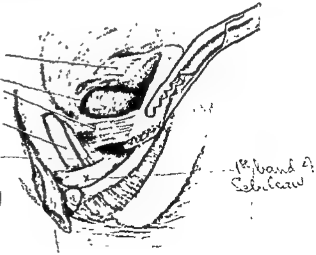

FIG 97 —Figure shows manoeuvre for exposing the scalenus anterior and the rhomboid ligament before sectioning them—right side

smaller resections as to number and length of ribs removed should be done, the latter especially, as too free an uncovering of the anterior part of the apex may lead to severe paradoxical respiration and a fatal outcome. The third and second ribs are removed in the orthodox manner. The posterior end of the first rib is freed of its periosteum for about 1½ inches and this part of the rib is excised. The periosteum is now stripped off the undersurface of the rib as far as the cartilage. This generally can be done by swab pressure. The structures having been gently elevated from the upper surface of the rib, the attachment of scalenus anterior to the inner margin can easily be seen, and divided with scissors if the rib is pulled downwards and outwards with sequestrum forceps. The innominate vein is now pushed off the posterior aspect of the rhomboid ligament by swab pressure and the ligament is sharply divided (Fig. 97). Failure to do this means that rib section will not go far enough forwards.

Paradoxical respiration

(d) *Apical mobilization*

The ribs having been resected, the apex is then mobilized.

Mobilization is carried out in the extrafascial plane, that is, above the level of Sibson's fascia. This fascia is the specialized portion of the endothoracic fascia which covers the dome of the pleura and prevents the lung from ballooning into the neck, as it does when this fascia is ruptured.

Endothoracic fascia

Sibson's fascia is attached to the inner margin of the first rib and to the tip of the transverse process of the seventh cervical vertebra. From these attachments the fascia arches over the dome of the pleura and is continuous with a sheet of fascia which invests the mediastinum. The first thoracic nerve, as it winds round the neck of the first rib, pierces the fascia to reach the upper surface of the rib, and separates the fascial attachment to the neck of the first rib from that attached to the transverse process of the seventh cervical vertebra. This latter band separates the first thoracic nerve from the subclavian artery. The thickened fascia of the scalenus anterior and a few of its fibres which are inserted into Sibson's fascia separate the subclavian artery and the subclavian vein. These three bands are known as the bands of Sebileau.

FIG. 98—The second band of Sebileau after division of the first band—right side.

Bands of Sebileau

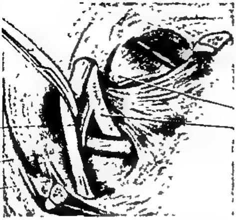

FIG. 99.—The third band of Sebileau before division—right side

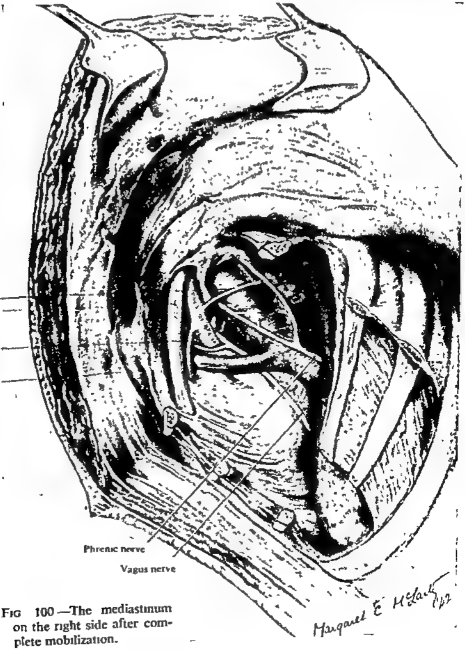

FIG. 100.—The mediastinum on the right side after complete mobilization.

Technique of apical mobilization.—The technique of mobilization is intimately concerned with these bands.

The first thoracic nerve is clearly exposed by incision of its fascial covering. This permits the freeing of the deep surface of the first band from the nerve, which can then be divided with scissors or a knife. The first intercostal branch of the first thoracic nerve is then divided and this nerve can be pushed upwards to expose the second band (Fig. 98). This band is defined by incising the fascia covering the artery, from which the band can be easily freed by inserting, parallel to the course of the artery, a blunt pair of artery forceps and then gently opening them; the posterior margin of the band can be similarly defined between it and the vertebral bodies. This band is triangular in shape, the apex projecting inwards between the artery and vertebrae; on

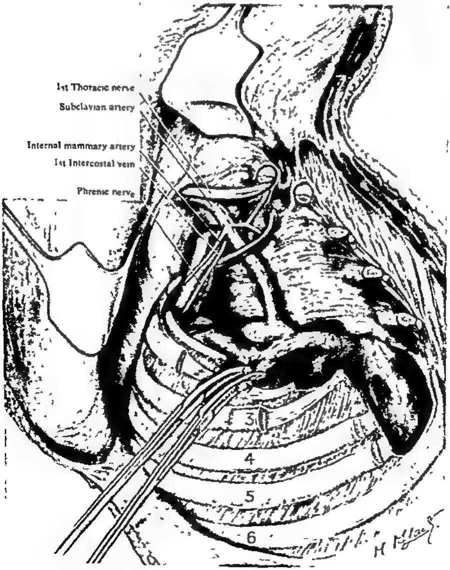

FIG. 101.—Figure shows the mobilized left apex with division of the posterior ends of the fourth and fifth ribs.

its deep surface runs the superior intercostal artery and the highest intercostal vein, and complete division of the band entails laying bare these structures.

Extrapleural mobilization of apex

Failure to divide the band completely, leads to mobilization of the apex extrapleurally, thus leaving the mediastinal layer of the endothoracic fascia untouched (Fig. 99). The third band is divided, usually with scissors, and this brings into view the internal mammary artery. This artery is invested, as it were, in the endothoracic fascia, and to keep in the extrafascial plane it is necessary to divide the fascia below the level of this vessel. By sharp dissection it is now a simple process in the easy case to dissect the whole of the apex from the mediastinum and to cut the intercostal bundles and the arteries and nerves, thus allowing the area mobilized to retract concentrically.

Sharp dissection

When the mobilization has been completed (Figs. 100 and 101) and haemostasis secured, the muscular and skin layers are sutured. A dressing is applied and the hemithorax is strapped so as to prevent any paradoxical movement.

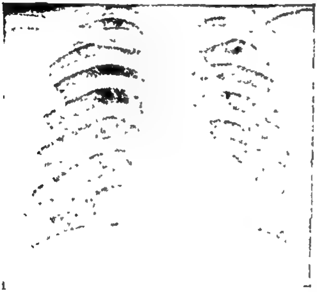

FIG 102. *Case* 3.—Skiagram shows cavity at left apex with infiltration at the base.

(5) Second stage

Condition of patient

The second and succeeding stages are carried out *at fortnightly intervals* only if the patient's condition will allow of them; this interval makes successive interventions technically easier, but, of course, the prime consideration is, and should always remain, the patient's ability to withstand the intervention.

FIG 103. *Case* 3.—Skiagram shows cavity ballooned and held out at apex.

The second stage is carried out through the same incision as that used for the first stage. The skin wound is excised and the musculo-cutaneous flap is

elevated, the apical space (Sembs's space) is opened, the sero-sanguineous fluid is aspirated and any clot which is present is removed. In the average case, portions of the fourth, fifth, sixth and seventh ribs are removed, and further mobilization of the apex is undertaken if it is indicated. This is much more difficult than during the first stage and needs more experience. Mobilization is commenced through the bed of a newly resected rib, the periosteum is incised and the extrafascial space entered; from this point, mobilization is carried forwards, upwards and downwards so far as is necessary.

Mobilization of lung

FIG. 104. *Case* 3.—Skiagram taken 2 years after performing left phrenic crush Cavity in left apex and basal infiltration still present but harder.

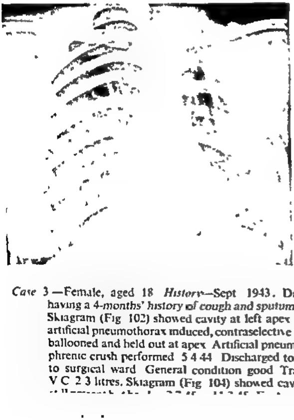

FIG. 105 *Case* 3.—Skiagram taken 1 year after two-stage thoracoplasty was performed. Satisfactory apical collapse, no evidence of cavitation.

Case 3—Female, aged 18 *History*—Sept 1943. Diagnosed pulmonary tuberculosis having a 4-months' history of cough and sputum. Oct 1943: Admitted to hospital. Skiagram (Fig 102) showed cavity at left apex with infiltration at the base Left artificial pneumothorax induced, contraselective Skiagram (Fig 103) showed cavity ballooned and held out at apex Artificial pneumothorax abandoned. 2 12 43. Left phrenic crush performed 5 4 44 Discharged to sanatorium 15 1.45: Readmitted to surgical ward General condition good Trace of positive sputum E.S R 9. V C 2 3 litres. Skiagram (Fig 104) showed cavity in left apex Basal infiltration [illegible]

Subsequent skiagrams show that condition remains satisfactory. One sputum test negative

(6) Third stage

The third stage is carried out in the same way, but it will be necessary to make a small incision backwards and downwards from just in front of the vertical limb of the incision. Through this, the eighth, ninth and tenth ribs are excised without lung mobilization.

Case 4.—Female, aged 21. *History*—Aug. 1936 diagnosed pulmonary tuberculosis; indifferent rest in bed for 10 weeks. July 1937. Haemoptysis 3–4 ozs. No treatment July 1938. Pleurisy in the right side. Rest in bed for 7 weeks. Then under observation until admitted to hospital. March 1939: Admitted to hospital. Right artificial pneumothorax attempted but failed. *26.10.39: Admitted to surgical* ward. General condition fair Pyrexia to 99° F. Sputum ½–1 oz positive E.S.R. 36 V.C. 1 litre Skiagram (Fig. 106) showed multiple cavities in the right lung which is atelectatic. There was marked mediastinal displacement to the right side The left lung showed no abnormality. 22.11.39: *First-stage thoracoplasty*. Resection of the 1st, 2nd and 3rd ribs with portions of the posterior ends of the 4th and 5th ribs and mobilization of the apex. 6.12.39: *Second-stage thoracoplasty*. Resection of the remainder of the 4th and 5th ribs and portions of the 6th and 7th ribs with further mobilization

Fig. 106 *Case* 4.—Skiagram shows multiple cavities in the right lung which is atelectatic There is marked mediastinal displacement to the right side The left lung shows no abnormality.

Fig. 107. *Case* 4—Skiagram shows collapse without any evidence of cavitation.

20.12.39: *Third-stage thoracoplasty* Resection of the 8th, 9th and 10th ...d to hospital. ...3rd rib. ...11 41: ...8: Seen ...c. 1947 ...ough or ...tion

The extent of the operation will depend upon the general condition of the patient, the phase in the evolution of the lesions—whether exudative or fibrotic—and the condition of the lung—whether it is soft or firm and solid. A patient in poor general condition with predominantly exudative disease in a soft lung demands a limited resection, perhaps only one rib, or two at the most, and ■ correspondingly small mobilization. The predominantly fibrotic lesion in a solid apex in ■ patient whose general condition is good, can be submitted to the resection of three ribs, with portions of the posterior ends of the fourth and fifth, with mobilization of the apex down to and over the aortic arch on the left or the vena azygos major on the right. The lack of paradoxical movement in the latter group makes extensive mobilization a relatively safe procedure. In both groups of cases, however, in order to obtain the best results it is necessary to carry out apical mobilization either at the first stage or at subsequent stages until not only the cavity but also the area of the draining bronchi ■ relaxed; this can be ensured by mobilizing to the level of soft lung or to the lung root.

Extent of operation

Apical mobilization

(7) Accidents during operation

(a) *Opening of the cavity*

The accident most to be feared during the operation is opening of the cavity. This accident should be avoided in cases in which the disease is relatively recent, if the mobilization is carried out by sharp dissection in the extrafascial plane. It is most likely to happen if blunt swab, or finger, dissection is used, or it may occur in old-standing cases when ulceration has extended to the lung surface, and the cavity wall is formed by the periosteum of the vertebral bodies. In the latter group, opening of the cavity is inevitable if mobilization of the apex is undertaken.

Closure of the cavity.—If the cavity is opened, it should be cleaned out and then packed with a damp gauze swab. Further mobilization of the apex should be carried out until the level of soft lung is reached; this will probably entail further rib resections. In cases with a firm apex, resection should be carried down to the seventh or eighth rib; this is a reasonably safe procedure in this type of case, and it ensures embedding of the scapula and avoids the necessity of undertaking a further intervention on the upper part of the lung. Even in cases with a soft apex, it would be a justifiable procedure unless the risk was prohibitive. After wide mobilization of the apex has been carried out, the pack ■ removed from the cavity. Control of the draining bronchi will be evinced by the absence of respiratory blowing. The edges of the opening are cleanly excised and are then sewn up with catgut. This suture line is further invaginated with two layers of sutures, which can be done without tension if mobilization has been satisfactorily carried out. In three cases cavities were opened and were treated by this method without post-operative complication. In another case one cavity, treated by limited mobilization and suture only, ruptured in the post-operative period, giving rise to a fatal extrapleural infection. On three occasions unsuspected small infected pleural pockets have been similarly treated without untoward results.

Further rib resections

Fatal extrapleural infection

(b) *Opening of the pleura*

Opening of the uninfected pleura is a not uncommon accident and occurs most commonly over the anterior and mediastinal aspect of the apex. On

these occasions, the surrounding pleura should be freed so that the hole can be closed without tension. Holes up to one inch or so can be closed with an arterial clamp and the pleura ligated. This avoids puncture of the pleura with a needle; often in thin pleurae such a puncture may tear and give rise to a larger hole. After the pleura is closed, air should be aspirated from the pleural cavity with an initial artificial pneumothorax needle. This eliminates the physiological upset which occurs with a pneumothorax after the chest wall has been mobilized.

Closure without tension

Aspiration of air

(c) *Damage to sympathetic trunk*

Damage to the sympathetic trunk occurs frequently. The paralysis may be temporary or permanent. When temporary, it doubtless results from contusion of the sympathetic trunk and recovery occurs in a few weeks. Permanent paralysis results from transection of the trunk when the apex is firmly adherent in the costovertebral angle, and is in most cases undertaken deliberately in order to obtain efficient mobilization. The disability of a Horner's syndrome is a small price to pay for effective control of the disease and the patients quickly get used to the ptosis which is their chief cause for complaint.

Permanent paralysis

(d) *Damage to vessels*

Damage to large vessels is extremely rare, but may lead to serious results The innominate vein has been opened on two occasions during re-operations; on one occasion, the hole in the vein was successfully sutured while the vein above and below the tear was controlled with the fingers; in the second case the patient succumbed to an air embolus.

Innominate vein

The subclavian artery was tied on one occasion, without ill effect, to control the hole left by an avulsed superior intercostal artery.

Subclavian artery

(e) *Damage to thoracic duct*

The thoracic duct may be damaged. This may be recognized at the time and, if so, the duct should be ligated. The damage, however, may not be recognized until the post-operative period or until the second stage is undertaken.

FIG 108 *Case 5*.—Skiagram shows left lung—infiltration and multiple cavities affecting all zones, right lung—some infiltration of right upper zone

Case 5.—Female, aged 34. *History*—Oct. 1941 Diagnosed pulmonary tuberculosis with laryngeal involvement 9.2.45: Admitted to hospital, having spent the intervening time in resting in bed, either at home, in hospital or in a sanatorium. On admission, general condition poor Persistent cough 1 oz. sputum purulent—positive Night sweats and loss of weight. Temperature ranging up to 100°–100.8° F. E.S.R. 63. Skiagram (Fig 108) showed: left lung—infiltration and multiple cavities affecting

(Fig. 109). Sputum increased to 10 ozs. daily, ...
1.11.45: Patient's condition improved. Temperature normal. Sputum 2 ozs, non-foetid. 15.11.45: *Second-stage thoracoplasty* Excision of regenerated portions of 2nd and 3rd ribs and resection of 4th rib, with mobilization of apex. Following this, patient's general condition was good but temperature 101° F. Thin yellow purulent fluid was aspirated from Sembs's space. Proved to be chyle. 27.11.45: *Third-stage thoracoplasty* Sembs's space filled with fibrin containing fat and liquid chyle. Ribs 5, 6 and 7 resected and apex mobilized

FIG. 109. *Case* 5.—Skiagram taken after first-stage thoracoplasty performed Lung seen to be atelectatic.

FIG 110. *Case* 5.—Skiagram taken 3 years after completing four-stage thoracoplasty. Cavities closed and lesion in right lung calcified.

Ballooning of Sembs's space

In the post-operative period, ballooning of Sembs's space occurs; the patient not infrequently runs a pyrexia of up to 101° or 102° F. The fluid aspirated from the space may be erroneously thought to be pus. The patient's general condition, however, is infinitely better than it would be with an infection of such a wide area. Investigation of the fluid will quickly determine the diagnosis. Other cases run a silent course and are recognized only when the space is reopened. If the chyle is intimately mixed with blood, recognition of the true state of affairs may be difficult. Observation of the space after it has been swabbed out cleanly will demonstrate that the fluid re-collects and the hole in the duct can be located. Ligation of the duct above and below does not lead to any disability. The anastomoses between the right and left sides are so numerous as to make interruption of the duct of little moment, and there has not been the slightest evidence of upset in the patient's nutrition.

Ligation of duct

(8) Post-operative course and supervision

(a) Position in bed

After operation, the patient is placed in bed in the semi-upright position while still in the theatre; this position facilitates respiration and coughing If the patient is shocked, the same position is used but the foot of the bed is raised on blocks.

(b) Oxygen

It is advisable to give oxygen in the early post-operative phase to the majority of patients. It decreases the respiratory effort and, in consequence, the degree of paradoxical movement and the risk of bronchogenic spread of the disease, and probably the risk of spontaneous pneumothorax. Severe oxygen lack is easily recognized, but minor degrees can be easily overlooked unless borne in mind.

(c) Vomiting

Vomiting occurs despite the type of anaesthesia used and may be very distressing. Persistent vomiting bears a direct relationship to the amount of fluid taken by mouth; the substitution of rectal or intravenous fluids are the most effective methods for its control. For minor degrees, the limitation of fluids by mouth to intermittent sips, with rectal feeds, is sufficient.

Methods of control

(d) Other considerations

(i) *Pain.*—This is not considerable except after the second stage when the scapula is embedded, and when cough is troublesome. Morphine in doses of $\frac{1}{6}$ grain should be given 4-hourly if necessary but, in the majority of cases, Veganin will suffice after the first 48 hours.

Morphine

(ii) *Coughing.*—After thoracoplasty, coughing is often difficult and painful. Despite this, the patient should be encouraged and helped to raise his secretions. Morphine, to allay the pain, is of great help. In the hours following operation, the patient's chest should be supported by a nurse's hand over the resected area; later he can support it himself. Retained secretions give [illegible] to spread and atelectasis, and to minimize this risk it is of value, if [illegible]

Support of chest

of undoubted value between stages in improving the general condition. A haemoglobin value in the region of 70 per cent warrants a transfusion.

(iv) *Physiotherapy.*—Post-operative diaphragmatic breathing and postural exercises for the arm and spine are started on the second or third post-operative day. After the second stage, however, movements of the arm beyond abduction to the right angle are not undertaken for the first week, in order that the scapula may be firmly embedded. Scapular movements before this time lead to troublesome slipping of the scapula on the unresected seventh or eighth rib which may necessitate resection of the latter. *Slipping scapula*

Early correction of postural deformities mitigates to a large extent the residual scoliosis which is unavoidable after thoracoplasty with apical mobilization, in which the lateral stays of the vertebral column, the costo-transversal and the costal attachments of the erector spinae have been detached.

(v) *Rest in bed.*—The patient is kept in bed for 12 weeks following the last stage of the operation. This period allows the functional stenosis, produced by the relaxation, to become organic and any exudative process to heal under the best conditions. Earlier cases submitted to early ambulation proved disappointing in that apparently closed cavities reopened after exercise.

(9) Post-operative complications

A great number of the common post-operative complications can be avoided or mitigated if the foregoing points are borne in mind.

(*a*) *Atelectasis*

Atelectasis is by far the commonest complication and occurs in about 20 per cent of cases, although all cases may not be recognized unless close clinical and radiological control is practised.

The cause is undoubtedly the aspiration of thick mucus or muco-pus into the bronchi. The factors favouring this are: (1) paradoxical movement of the lung, when secretions from the diseased area are sucked into the sound base. The paradoxical movement of a paralysed diaphragm satisfactorily explains the increased frequency (2½–3 times) of atelectasis occurring if thoracoplasty is undertaken when the diaphragm is paralysed; (2) secretions are rendered thick by the necessary pre-operative medication, mainly the hyoscine; and (3) pain limiting the patient's cough. *Cause*

(i) *Simple atelectasis.*—In the majority of cases the atelectasis is simple and causes no constitutional disturbance, and so may be overlooked. Physical signs may be very misleading for, not infrequently, breath sounds are diminished or absent in the uncomplicated case as the result of the immobility of the hemithorax in the early post-operative phase. Dullness and evidence of mediastinal displacement, that is, of the trachea and apex beat, are the only reliable signs, but confirmation should always be sought by radiography. The atelectatic lung is blacked out and the heart and mediastinum are displaced to the affected side. *Breath sounds absent* *Radiography*

In the majority of these cases the obstructing plug becomes dislodged, or it liquefies, and the lobe re-aerates. This usually occurs in 4–5 days, occasionally in the course of 24 hours, and does not affect the clinical course or delay the operative stages if adequate prophylactic treatment has been instituted.

(ii) *Infected atelectasis.*—In some cases, however, the onset of collapse is accompanied by severe constitutional disturbance, when the patient not only

looks, but feels, ill. A great deal of difficulty is experienced in raising the sputum which is purulent, whether from pain, from the tenacious character of the sputum or from both. Physical signs are those of collapse, with râles and rhonchi to a variable degree.

Physical signs

These signs are associated with a more or less severe inflammation of the lobe behind the block, varying from a purulent bronchitis to, more rarely, a lung abscess.

More drastic measures are necessary in this group and should include early bronchoscopy, with aspiration of the secretions; more frequent sessions of postural drainage; and the administration of chemotherapeutic agents. Bronchoscopy is preferably done in the patient's bed. Postural drainage in such ill patients must be done carefully: the patient is lowered on to the sound side and the foot of the bed is raised on blocks, the patient being encouraged to cough up the secretions in this position. A nurse should be in attendance at this time and for the whole period when the patient is really ill.

Chemotherapy

Lung abscess

A lung abscess, once diagnosed, should be drained. Later, this will mean a considerable modification of the thoracoplastic procedure. Two such cases have been treated with success.

(iii) *Atelectasis with additional tuberculous disease.*—The majority of lobes in which the atelectasis does not clear up, and in which abscess formation does not occur, become the seat of tuberculous disease. In these cases toxaemia and the production of sputum are prolonged. Although there is eventually an attempt at re-aeration, a coarse granular mottling of the lobe remains, and, if further treatment is not instituted, excavation may occur. When the patient's condition permits it, a further rib resection should be done to cover the affected area.

Toxaemia

Further rib resection

The practical outcome of the above is to proceed to further rib resection in all cases of basal collapse which have not re-aerated in 3 weeks. In the majority of cases in which this is practised, evidence will be found of the pre-existence of tuberculous foci by the areas of calcification which are present in the lower lobe.

(*b*) *Spread of tuberculosis*

Distinction should be made between true spread of the disease and reactivation of pre-existing foci. The latter is much more frequent than is generally appreciated; the cause of the reactivation is a combination of lack of resistance and the mechanical effects of the operation, inducing a hyperventilation. True spread results from bronchiolar occlusion giving rise to patchy atelectasis on which is superimposed tuberculous spread. The mechanism of its production is similar to that in the gross atelectasis: hyperventilation and paradoxical movement in patients with a fair quantity of sputum. Owing to the small diameter of the occluded bronchus spontaneous recovery is scarcely to be expected. Spreads of this kind on the side of the thorocoplasty are best dealt with by extension of the resection when the patient's condition permits it.

Bronchiolar occlusion

(*c*) *Spontaneous pneumothorax*

[illegible] in cases [illegible]. This [illegible] egion is easily understood when the presence of [illegible] of a healing lesion is considered. One of these bullae may rupture as the result

Emphysematous bullae

of the hyperventilation which may occur after, or during, the operation. Its early recognition and relief are important. Simple aspiration of air may suffice, but it may be necessary to leave *in situ* a needle which has been connected to an under-water drain or to a negative-pressure suction machine until the broncho-pleural communication has healed.

Aspiration

(*d*) *Infection*

Infection of the wound or of the extrafascial space may occur, which may be either pyogenic or tuberculous.

(i) *Wound infection.*—Wound infection is the commoner and is usually pyogenic. This infection occurs at the time of the operation and is due to faulty aseptic technique. The origin is not uncommonly in the patient's skin. Many of these patients suffer from acne, which should be cleared before operation, even though this proves difficult and is time consuming.

Faulty aseptic technique

Infection of the wound, if superficial to the muscles, will remain confined to this plane, as it will to the extrafascial space if the muscular suture line remains intact. Unrecognized infection of the space, however, generally leads to rupture of the suture line, and infection of the wound occurs.

Any prolonged or pronounced post-operative pyrexia should be investigated. Pulmonary causes usually can be recognized by clinical and radiological means. X-ray examination may show ballooning of Sembs's space

Pyrexia

transudation of serum, infection or haemorrhage, or as a complication of damage to the thoracic duct. In all cases, aspiration and bacteriological examination of the fluid in Sembs's space should be carried out under strictly aseptic precautions, even in those cases in which there is ballooning of the space, despite satisfactory evidence of pulmonary infection.

(ii) *Pyogenic infection of Sembs's space.*—Infection of Sembs's space is rare.

Sterilization of the space with penicillin is a difficult procedure owing to the presence of clots, and aspiration and injection of penicillin should not be persisted with if the response is not rapid and immediate, or if there is any suspicion that the posterior wound is breaking down. Under these conditions operative intervention is preferable. The procedure adopted will depend upon the amount of clot present in the space. Commonly there will be, radiologically, an obvious fluid level in the space. In these cases an intercostal tube is inserted through a cannula into the space high in the axilla and the tube is attached to a suction pump running at —½ centimetre Hg.

Treatment

Operative intervention

Drainage of the space will delay the second stage which generally can be undertaken in about 1 month. This stage is modified in that the rib resection is carried out without reopening the space; great care must be taken in resecting the uppermost rib.

Modification of second stage

In some cases, however, there will not be a fluid level, the space being uniformly opaque due to a mass of clot in it. This should be treated as for severe haemorrhage into the space.

(iii) *Tuberculous infection of Sembs's space.*—Tuberculous infection of the space results from rupture of the cavity into the space or damage to lung or lymphatics during the operation. The complication is uncommon, occurring in less than 0·5 per cent of operations. Evidence of its occurrence usually presents 6–8 weeks after operation by a quiet giving way of the wound with the discharge of a varying quantity of pus; the margins of the sinus have an unhealthy surface which, on biopsy, proves to be tuberculous granulation tissue. There is usually some pyrexia, although rarely high unless there is a superadded secondary infection.

Biopsy

Treatment

The condition, when well established and drained, constitutes one of the most intractable of the complications. Before the advent of streptomycin, the outlook for ultimate cure was almost hopeless, establishing and maintaining good dependent drainage being the only possible method of value. Closure of the space presents a very formidable procedure, entailing resection of the body of the scapula and a large portion of the clavicle, and then without the certitude of success. Limited experience at present suggests that if the external wound can be kept intact, injection of 1-gramme doses of streptomycin on alternate days will lead to retrogression of the disease and to its ultimate healing or firm encapsulation.

Streptomycin

(iv) *Tuberculous infection of the wound.*—Tuberculous infection of the wound occurs as a complication of the above. Rarely, however, it may occur as an isolated phenomenon, and then it reacts favourably to the relatively simple measures of drainage, with or without curettage.

(v) *Haemorrhage into Sembs's space.*—In all cases there is some oozing into the space which is of no clinical significance. Occasionally, severe haemorrhage occurs, sometimes enough to cause rupture of the suture line and give external evidence of bleeding. Most commonly, however, the haemorrhage is concealed. Tachycardia, and bulging of the infraclavicular hollow and axilla, coupled with the radiological picture, determine the diagnosis. Radiologically there is an opacity in the position of the space with a convexity bulging down into the aerated lung, and evidence of an interstitial emphysema caused by displacement of the air from the space into the intermuscular planes.

Treatment

When the haemorrhage has been severe, replacement of lost blood is the first essential step. The fate of the suture line will determine further steps. If the suture line is sound, as is most commonly the case, nothing further need be done until the next stage when the clot can be turned out. If, however, the suture line has given way the wound should be reopened immediately; the clot should be turned out and any bleeding-point secured, though rarely is one obvious. The muscle planes should again be carefully resutured after the introduction of penicillin. Penicillin parenterally is beneficial in both infected and non-infected cases when surgical intervention is used.

There need not be any delay in proceeding with subsequent stages if the necessary prompt action is taken in dealing with the complications.

(10) Bilateral thoracoplasty

In cases in which [illegible] to wait [illegible] the at least 4 months [illegible] remaining in a sanatorium.

Case 6 [illegible]

apparently closed Right artificial pneumothorax attempted but [illegible]
Transferred to surgical ward Skiagram (Fig. 111) showed cavity right apex. ? small

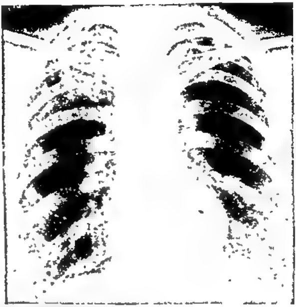

Fig 111. *Case* 6.—Skiagram shows cavity in right apex; ? small cavity at left apex.

Fig 112. *Case 6.—Skiagram* taken 7 months after performing three-stage thoracoplasty. Skiagram does not show any evidence of cavitation in left lung.

[illegible]

attacks of fever. Sk...
posit...
B.S.R...
Tomo...
and ...
mobil...
Sputum negative ... of 4th rib. Skiagram (Fig 115) showed cavity closed ... 4th ribs resected. Apical

Note—Fluid level is in subscapular space and not intrapulmonary.

FIG. 113 *Case 6*.—Skiagram shows cavity in left apex with some infiltration.

FIG 114. *Case 6*.—Tomograph, confirming presence of apical cavity revealed in Fig 113

(11) External drainage of the cavity

FIG 115. *Case* 6 —Skiagram taken after performing left thoracoplasty, showing cavity closed.

External drainage can be undertaken as an adjuvant to thoracoplasty or as a definitive method of treatment.

Monaldi drainage

As an adjuvant, drainage is established by means of a catheter introduced into the cavity after the method of Monaldi (1939) (Fig. 116). The type of case in which this is most valuable is that with large cavities of the distension type, preferably without a great deal of surrounding infiltration In the experience of workers in Great Britain and in the United States of America, closure of the cavity does not occur; this is to be expected as the draining bronchi are not affected by the decompression measures Some workers maintain that preliminary drainage decreases the necessary extent of the thoracoplasty; this, however, does not coincide with the author's experience.

(a) *Technique*

It is essential to determine whether or not there is a pleural symphysis at the site of puncture by attempting to induce a pneumothorax. If there is a free space, this should be obliterated by the introduction of either 5 minims of a 10 per cent solution of silver nitrate or 10 cubic centimetres of blood, or by the insufflation of talc, followed by immediate aspiration of the air in the pleural space. The patient should lie on his face for 24–48 hours following the introduction of one of those agents. A fresh attempt at induction should be made 10 days or so later; the catheter should be introduced only when it is certain that a symphysis is present; failure to observe this rule will lead to pleural infection.

The operation is done under local anaesthesia and fluoroscopic control. *Anaesthesia*
When the latter is not available, a careful study of the skiagrams will give sufficient guide.

The absence of a pleural space being assured, a long graduated artificial pneumothorax needle is introduced into the cavity and the intracavitary pressures are registered. The depth and direction of the needle are carefully noted. The needle is withdrawn and a special trocar and cannula which is also attached to the pneumothorax box, is inserted in the same direction and to the same depth as the needle. During the introduction, the manometer usually registers a slight positive pressure, but as soon as it enters the cavity respiratory variations are observed, most commonly on the mean positive side, for

example, from -2 to $+6$ centimetres of water. The trocar is withdrawn, and the catheter is threaded through the cannula into the cavity. It is wiser to thread an excess of catheter into the cavity so that at least a complete coil has been inserted. The cannula is now withdrawn, and a specially constructed rubber shield is drawn over the catheter on to the skin, the shield being fixed on the skin with strapping; this fixes the catheter. It can, however, be fixed directly to the skin with strapping. The catheter is occluded by a spigot which is removed when the patient returns to the ward The catheter is attached to an aspirating pump registering from -6 to -8 centimetres of water.

FIG. 116. *Case 7.*—Skiagram shows catheter *in situ* for right Monaldi drainage.

Great care must be taken to keep the lumen of the tube clear for the first 3 or 4 days. This may entail aspiration of the tube with a syringe or the injection of a few cubic centimetres of air through the tube. If the tube becomes blocked in the early days and the patient has any cough, secretions are coughed outside the tube into the fascial planes and a tuberculous cellulitis ensues.

Intermittent drainage

Drainage should be intermittent, that is for 8–10 hours a day, and should continue until the cavity is reduced to a track.

When there is a well-established track, usually after 4 or 5 days, the catheter can be withdrawn until it is straight within the cavity.

The progress of the case is checked radiologically, until there is no obvious cavity to be seen on the plain skiagram after the injection of Lipiodol.

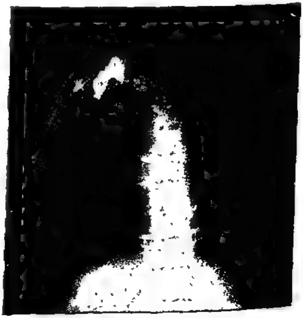

FIG. 117. *Case 7*—Skiagram shows cavity in right apex markedly reduced in size.

Bacteriological control demonstrates the

disappearance of tubercle bacilli from the discharges after about a month's drainage.

When the cavity has ceased to contract any further and if the patient's general condition permits, a thoracoplasty with apical mobilization should be undertaken. Technically, this is more difficult than the operation done without drainage, since it is necessary to restrict the extent of forward resection of the ribs in order to avoid opening into the drainage track. In view of this it is advisable when possible to perform the drainage through the second interspace.

The catheter is withdrawn after the thoracoplasty has been completed and the sinus heals.

FIG 118 *Case* 7.—Skiagram, taken 8 months after performing three-stage thoracoplasty, showing good collapse of right apex.

Case 7.—Female, aged 16 *History*—4 11.42: Admitted to hospital after a diagnosis of pulmonary tuberculosis with bilateral disease had been made in

FIG 119 *Case* 7.—Skiagram taken 5 years after thoracoplasty There is now no evidence of cavitation in right side. Left apex—some fibrosis and emphysema

torium to complete course of rest in bed and for rehabilitation. 23 12.43: Discharged home. Skiagram (Fig. 118) showed good collapse right apex. Satisfactory left artificial pneumothorax 20 5 46. Very well No cough or sputum Left artificial pneumothorax abandoned. 30.1 48: Very well. No cough or sputum Skiagram (Fig 119) No evidence of cavitation of right side Left apex — some fibrosis and emphysema.

(b) *Speliotomy*

Speliotomy or definitive external drainage is performed in the same manner as drainage of an acute lung abscess.

Indications for use.—This method of treatment is being more commonly used than heretofore. The operation is most suitable for the solitary cavity with little or no surrounding infiltration when thoracoplasty is contra-indicated, either because the patient's general condition will not permit of it, or because the site of the cavity is such that the thoracoplasty procedure must be of such an extent to obtain closure of the cavity as would unnecessarily collapse a large amount of healthy lung, as, for example, cavities in the apical part of the lower, and the pectoral segments of the upper, lobes.

Packing of cavity

The cavity after drainage is packed lightly with gauze until healing takes place. It may be necessary to cauterize the bronchial openings with silver nitrate to hurry the rate of closure.

RESULTS

Total number of cases		304
Early mortality (patients unable to leave hospital)		29 (9 5 per cent)
Number of cases followed up	243	
Cavity closure and sputum negative or no sputum	209 (86 per cent)	
Cavity unclosed or sputum positive	34 (14 per cent)	
Late mortality $\left\{\begin{array}{ll}\text{before 1 year} & 7\\ \text{after 1 year} & 8\end{array}\right\}$	15 (6·2 per cent)	
Number of cases not followed up recently	17	

8. LUNG RESECTION

Resection of the lung for pulmonary tuberculosis, although it has been extensively used in the United States of America, is still to a certain extent *sub judice* in Great Britain. It should be pointed out that only very recently has streptomycin been available here for such cases.

(1) *Indications for use*

(1) Closed tuberculous lesions or tuberculomas.

(2) Tuberculous bronchostenosis, with infection or cavitation behind the stenosis.

(3) Cavities occurring in the basal segments of the lower lobes when a satisfactory artificial pneumothorax cannot be established.

(4) Cases of rupture of the cavity into an artificial pneumothorax with its associated empyema.

(a) *Tuberculoma*

Closed tuberculous lesions are most commonly submitted to resection on either a tentative diagnosis of a tuberculoma or a mistaken diagnosis of a neoplasm. Occasionally, however, cases with a solid lesion and a positive sputum are seen. Experience with this latter group shows that when the lesion has become overt, the tendency is towards progression and also that successful arrest of the process may be anticipated by resection. The striking

pathological finding in these cases is that the bronchus at the line of section is healthy, there being no evidence of tuberculous infiltration of the mucosa or submucosa, the latter being the site of most extensive spread. This may be

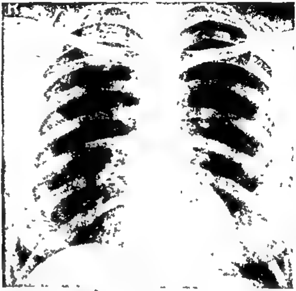

FIG 120. *Case* 8—Skiagram shows circumscribed shadow at right apex. Remainder of lung fields normal.

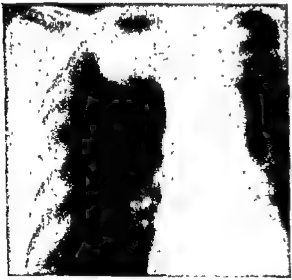

FIG 121. *Case* 8.—Tomograph (7-centimetre cut) shows shadow and absence of cavitation.

the main factor in the successful result and freedom from morbidity in this group.

Case 8.—Female, aged 35. *History*—Oct. 1942: Patient had pain in right upper chest and

(a)

(b)

FIG. 122. *Case* 8.—(*a*) Section of lobe, after right upper lobectomy had been performed, revealing a tuberculoma. The section shows a large fibro-caseous focus with small areas of calcification and, at the periphery, a narrow zone of tuberculous granulation tissue. (*b*) Histological section of lesion

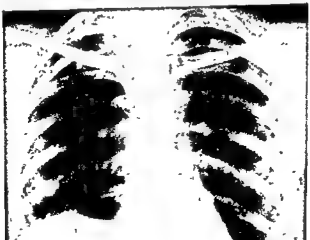

FIG. 123 *Case* 8—Skiagram taken 4 years after performing right upper lobectomy. The condition is seen to be satisfactory; right diaphragm still elevated.

(b) Tuberculous bronchostenosis

The statement by Alexander (1940) that tuberculous bronchostenosis with upper lobe cavitation is satisfactorily treated by thoracoplasty before the stenosis has become severe has been amply verified by experience. Cavitation in the lower lobe, however, constitutes a different category and the presence of the stenosis adds urgency to the need for other treatment. Similarly, secondary infection behind the block cannot be controlled by any relaxation procedure, and in both these groups lung resection is definitely indicated, provided that the process in the bronchus does not extend grossly to the line of projected section. It is true that histological sections of the cut end of the bronchus will show tuberculous submucous infiltration in all cases.

Stenosis

(c) Basal cavities

Difficulty in closure

Cavities in the basic segments of the lower lobe are notoriously difficult to close by any method of relaxation other than a perfect artificial pneumothorax, and even then a higher percentage fail to close than do those in the upper lobe under similar circumstances. The probable explanation of this difficulty in the closure of basal cavities is that the basal surface of the lung becomes adherent to the diaphragm and so concentric relaxation of the lower lobe is impossible. A combination of an artificial pneumothorax—which gives lateral relaxation—and a paralysis of the hemidiaphragm—which provides vertical relaxation—gives the nearest approach to the ideal. When an artificial pneumothorax cannot be established and when diaphragmatic paralysis in

FIG. 124. *Case 9.*—Skiagram shows pre-operative state of patient.

FIG. 125. *Case 9.*—Tomograph demonstrating excavation of both upper and lower lobes of left lung.

conjunction with pneumoperitoneum has failed, lung resection offers the sole chance of relief.

Case 9.—Male *History*—1942: Haemoptysis since 1936 *Skiagram of chest normal* Further haemoptysis. No investigation. March 1944: Cough; slight sputum; pain in left chest. Feb 1945: Radical operation for fistula in ano (Italy), following which small haemoptysis Skiagram of chest—diagnosis of pulmonary tuberculosis *Sputum positive.* Returned to England. June 1945. Went to sanatorium. Remained there till 2.4.47 when admitted *to hospital Feeling well* Two ozs positive sputum Afebrile E S R. 11. *Weight stationary* at 11 st 8 lb. Skiagram (Fig 124) showed mediastinal displacement to left Considerable excavation of both upper and lower lobes of left lung (Fig 125). *Bronchoscopy* Left main bronchus mucosa macroscopically normal. Upper and lower *lobe orifices not visualized owing* to distortion. Pus aspirated *from left main bronchus* *Bronchospirometry* V.C. 2·4 litres. *Right lung.* V C. 61 per cent Ventilation 7·2 litres. Oxygen uptake 240 c c. per minute. *Left lung.* V C. [illegible] per cent Ventilation 6 litres Oxygen uptake—nil Total oxygen capacity 242 c c. Right lung obviously responsible for the whole of the gas exchange. 15.5.47. *Left pneumonectomy.* Operation carried out in extrapleural plane to *hilum. Bronchus* amputated at carina One gramme of streptomycin left in pleura. parenteral streptomycin not available 15.7 47: Tubercle *bacilli* recovered from pleural fluid. Repeated aspirations with injection of streptomycin *into pleura.* 9.10 47. *Lateral thoracoplasty.* Ribs 1st to 7th (Fig. 126). One post-operative aspiration of pleural space with injection of 1 gramme of streptomycin. *15.11.47.* Discharged to sana*torium.* T.B. *negative* and in good condition. *23.1.48* · *General condition* good. Trace of mucoid sputum. T.B negative. Gaining weight. Fig. 127—*photograph of lung* removed.

FIG 126 *Case 9*—Skiagram taken after lateral thoracoplasty had been carried out

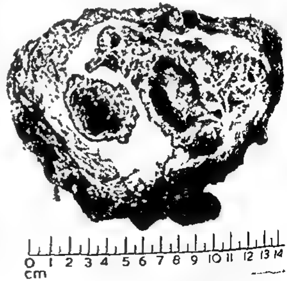

FIG. 127. *Case 9*—*Photograph of cut surface of resected* ... Note the two large cavities, one in the upper ... and [illegible] interlobar surface.

(*d*) *Ruptured cavities*

Rupture of a cavity into the pleural space occurs most commonly after an apparently successful division of adhesions or before the adhesions have been divided. This is usually a lethal complication and, even if the patient survives, there is a long period of morbidity with many operative interventions before the patient is once more stabilized. In view of the serious outlook, lung resection is not only a justifiable procedure but is the procedure which holds out for the patient the best prospect of success.

(2) Extent of operation

It is a prerequisite that the lung tissue to be left behind should be healthy; only after the gravest consideration should there be any departure from this rule. Before the decision to intervene has been taken, careful tomographic studies using sectional cuts should be made of the lung fields. Pre-operative bronchoscopic examination also is essential. *Tomography* *Bronchoscopy*

The principles of operative technique are the same as those used in carcinoma and bronchiectasis, with slight modifications. The lung is usually adherent to the chest wall and it is preferable to mobilize the lung in the extrapleural plane until the hilum is reached. This manoeuvre avoids the risk of damage to the lung and the opening of a tuberculous focus. In cases of ruptured cavity, excision of the pleura is as important as lung resection in the elimination of the diseased process. This will not be entirely possible, however, over the central part of the diaphragm and pericardial regions.

The hilum in the majority of cases will be found to be relatively soft and not infiltrated.

If lobectomy is contemplated, separation of the lobes should be done through healthy tissue. If this is not possible, pneumonectomy should be carried out. *Separation of lobes*

Thoracoplasty following pneumonectomy, and diaphragmatic paralysis following lobectomy, should be carried out so as to prevent over-distension of the remaining lung tissue in which there may be unsuspected lesions.

Thoracoplasty can safely be undertaken about 3 weeks after pneumonectomy if the patient's condition will allow. Phrenic interruption is carried out at the time of operation. The operative interventions are carried out concurrently with streptomycin therapy. Streptomycin, $\frac{1}{2}$ gramme twice a day, is given parenterally for from 2 to 4 days before operation until 2–3 weeks after the last operative intervention. At the time of closure 1 gramme of streptomycin is also left in the pleural cavity. Evidence is forthcoming that this form of biotherapy decreases the complication rate. *Streptomycin*

(3) Complications

The commonest complications are those of empyema and spread of disease in the remaining lung tissue. Both of these complications are more liable to occur if there is a bronchial fistula. Care in sectioning the bronchus at the level of the carina or the bronchus of the remaining lobe is, therefore, essential to prevent so far as is possible the risk of fistula formation. Blocking of the bronchus before opening the chest will prevent bronchogenic spread during the operation.

Other complications such as miliary spread of the disease and pericarditis are blood-borne in origin. Streptomycin undoubtedly helps to limit and control these accidents.

Only a limited number of tuberculous cases have been submitted to resection and no definite conclusions can be drawn from personal experience which is shown in the following table:

RESULTS OF LUNG RESECTION

Total number of cases	14
Lobectomy	9
Pneumonectomy	5
Empyema	
Pneumonectomy	2
Lobectomy	1
No early or late deaths	

REFERENCES

Alexander, J. (1940). *J. thorac. Surg.*, 10, 109.
Coryllos, P. N., and Ornstein, G. G. (1938) *J. thorac. Surg.*, 8, 10.
Monaldi, V. (1939). *Settim. med.*, 27, 231.
Roberts, J E. H. (1935). *Trans. med. Soc. Lond.*, 58, 204.
Sembs, C. (1936). *Acta chir. scand.*, 76, 561.
[References to other titles are given under Pulmonary Tuberculosis in the Index Volume. The subject is also dealt with under the heading of Lung Diseases: Tuberculosis in the *British Encyclopaedia of Medical Practice* (1938), Vol. 8, p. 182.]

PYLEPHLEBITIS

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1. DEFINITION

282.] Pylephlebitis is an acute suppurative thrombosis of a tributary of the portal vein which extends to the liver, often accompanied by the formation of multiple abscesses in relation to the terminal branches of the portal vein.

2. ANATOMY

Tributaries of portal vein

The main tributaries of the portal vein are: the superior mesenteric vein, which is of the greatest importance in pylephlebitis as it drains the viscera, usually the primary seat of infection; the pre-pyloric, left gastric and cystic veins which take little part; and the splenic vein, which receives the less important inferior mesenteric vein draining the rectum and the left side of the colon.

3. AETIOLOGY

Inflammatory processes

An acute inflammatory process in the gastro-intestinal tract is invariably present, and in the great majority of cases the appendix is involved. Pylephlebitis may complicate inflammation in many other places, though surprisingly rarely in view of the high incidence of such conditions. Although hepatic metastasis is common in amoebic dysentery, bacillary dysentery is not complicated in this way, and hepatic suppuration in typhoid fever is probably related to appendicular typhoid infection. Ulcerative colitis, especially in its chronic form, colonic diverticulitis, ulcerated carcinomas of colon and rectum, and suppurating thrombosed piles occasionally contribute cases.

Post-operative pylephlebitis

Pylephlebitis may also occur following any abdominal operation, including splenectomy, if sepsis supervenes, but it is practically unknown in gastric surgery. For practical purposes pylephlebitis is a rare and hitherto almost always fatal complication of acute appendicitis. In this condition, as in all

acute inflammations, there is venous thrombosis, which is readily followed by invasion of the thrombus by organisms. In the vast majority of cases the thrombosis does not extend, and the infected thrombi are not ejected as septic emboli to the liver, or if they are ejected do not occasion hepatic suppuration because of the rich double blood supply. As a rule hepatic suppuration is found when a large tributary of the portal vein is filled with a suppurating thrombus, and there is a continuous column of suppuration from the appendicular veins to the liver. But the portal tract is fortunately far less prone to simple or to infected thrombosis than the systemic venous system, though the results of thrombosis are far more severe. The reasons for this

FIG. 128.—The specimen shows a liver scarred by syphilitic cirrhosis and pale on account of portal vein thrombosis. It has been turned up to show the portal superior mesenteric and splenic veins, from which clot has been removed The lower jejunum and ileum are dark with early gangrene, and the coils of gut are gummed together by fibrin

relative freedom have not been determined, and might repay experimental analysis. As in the case illustrated in Fig. 128 suppurative portal thrombosis may occur without hepatic suppuration.

In this case the sequence of events was as follows:

(1) Hepato-lienal fibrosis (probably syphilitic in origin). (2) Splenectomy. (3) Septic thrombosis of splenic, portal and superior mesenteric veins. (4) Gangrene of small intestine.

4. BACTERIOLOGY

In most cases there is a mixed flora, but the haemolytic streptococcus is the most important pathogen. All the Gram-negative organisms of the colon may

be present, and some are usually found. In one case personally observed a streptothrix was found apparently alone, suggesting an acute actinomycotic infection.

5 MORBID ANATOMY

The portal vein and many or all of its tributaries are found at necropsy to be distended with a soft or semi-fluid thrombus, and the walls are thickened and inflamed. The liver is enlarged, but its surface is smooth. Abscess cavities, which are multilocular and crossed by strands of surviving tissue, are numerous as a rule and situated towards the centre of the organ. Single abscesses are rarely seen. The appearance is not unlike that of actinomycosis, but the fine "honeycombing" of that condition is not seen. Suppurative cholangitis shows smaller and usually far more numerous abscesses.

The following case record is of interest.

> A clerk, 18 years of age, was admitted with an attack of appendicitis of 48 hours' duration; an abscess was opened and drained, and 7 days later the operation was repeated, the abscess being traced up to the foramen of Winslow. Several pockets of pus were evacuated, but the temperature nevertheless showed a continuous hectic type. Leucocytosis, 13,500 with 89 per cent polymorphonuclear variety. Three weeks later distension of the right hypochondriac region occurred with considerable enlargement of the liver but operation revealed only the great liver enlargement, especially of the left lobe. A few days before death pus exuded from the umbilicus, around which was found localized peritonitis.
>
> The right lobe of the liver in section showed an advanced condition of portal suppuration. The liver weighed 97 ounces and was honeycombed by numerous abscess cavities, some of which could be seen on the surface about to perforate. The cavities were of varying size, with irregular walls and were loculated by bands—the remains of the connective tissue of the liver. They contained a greenish-yellow purulent fluid. The infection spread from the *appendix along the portal vein, the tributaries of which contained dirty, purulent* material, but no clot (Fig. 129). *Abscess cavities*

FIG. 129.—Portion of right lobe of liver in a case of advanced portal suppuration.

6. INCIDENCE

The largest series is that of Ochsner, DeBakey and Murray (1938), who in 68,198 cases of appendicitis found 247 or 0·36 per cent complicated by pylephlebitis. The incidence in appendicitis was, at the end of the last century, as high as 5 per cent, but has become much rarer.

7. CLINICAL PICTURE

Chill
Rigors
Jaundice

According to Hawkes (1938), who has stressed the necessity for early diagnosis, pylephlebitis in appendicitis is characterized by a chill which often antedates the acute illness. Rigors with a high temperature and severe prostration are warning signs before or after operation. Jaundice only rarely occurs, and usually suggests infection of the biliary tract. Blood cultures are usually negative and the total white-cell count is well above 20,000 per cubic millimetre. When hepatic suppuration supervenes, the liver is enlarged and tender.

8. DIFFERENTIAL DIAGNOSIS

Right-sided renal disease is the most frequent cause of error. Lobar pneumonia and inflammation of the biliary tract have also caused confusion. A not infrequent cause of erroneous diagnosis is infective hepatitis in the prodromal stage, and this condition is often ushered in with acute abdominal pain simulating appendicitis. When jaundice develops pylephlebitis is suspected. Unfortunately abdominal operations mistakenly undertaken early in the course of this disease are frequently fatal owing to haemorrhage from the operation site a week later when jaundice has developed. The statement that intraperitoneal haemorrhage following appendicectomy is frequently followed by jaundice from absorption of blood pigments is almost certainly wrong; the disease is, in fact, early infective hepatitis with abdominal pain

9. TREATMENT

(1) Surgical

The fall in the incidence of pylephlebitis following the practice of early appendicectomy indicates that ligation of the appendicular vein itself cuts short both emb[illegible] ligation of the ileocolic [illegible] be practised in selected cases. High portal ligation is useless, and [illegible] diagnosis and operation are essential.

(2) Drug therapy

(a) Sulphanilamide

The earliest successes were claimed with sulphanilamide, and a case is illus[illegible] [illegible]sion and calcifica[illegible] [illegible]d success in two cases.

(b) Penicillin

The haemolytic streptococcus is always sensitive to penicillin, and in relatively high concentrations, easily achieved by irrigation of abscesses, coliform bacilli are often affected. Penicillin has now been used in many cases; the

technique used successfully by Gamm (1945) was the intramuscular injection of 20,000 units of penicillin every 3 hours, with a total of 2,000,000 units, and injection of an hepatic abscess cavity with 25,000 units. On general principles treatment should be prolonged, and should extend for at least a week after the establishment of clinical cure.

Gamm's technique

(c) *Streptomycin*

Streptomycin has also been successfully employed, and has theoretical advantages since the coliform group is very sensitive to it, but in practice the group quickly becomes adapted, and in 4 days may require a dose 8,000 times greater. The drug has, however, been successfully employed by Wishart and Peterson (1947) where the clinical diagnosis was made without visual proof of hepatic involvement. The total dosage was 28·8 grammes given over a period of six days.

FIG 130.—The liver of a child showing irregular areas of inspissated bile salts, the late result of portal pyaemia The child suffered from jaundice, rigors and continuous pyrexia after appendicectomy. The specimen is unusual owing to the fact that the child survived for several weeks.

(3) Conclusions

There is much evidence, therefore, that chemotherapy and antibiotics offer a real chance of recovery even in well-established cases of hepatic suppuration, and their prophylactic value in arresting the spread of suppuration from the appendicular venous thrombus is undoubted.

REFERENCES

Gamm, K. E. (1945). *J. Amer. med. Ass.*, **128**, 1159.
Hawkes, S. Z. (1938) *Surg. Gynec. Obstet.*, **66**, 62.
Ochsner, A., DeBakey, M., and Murray, S. (1938) *Amer. J. Surg.*, **40**, 292.
Ottenberg, R., and Berck, M. (1938) *J. Amer. med. Ass.*, **111**, 1374.
Wilms, M. (1909) *Zbl. Chir.*, **30**, 1041.
Wishart, J. H., and Peterson, L. J. (1947) *J. Amer. med. Ass.*, **133**, 539.

[References to other titles are given under Pylephlebitis in the Index Volume. The subject is also dealt with under the heading of Liver Diseases in the *British Encyclopaedia of Medical Practice* (1938), Vol. 8, p. 80.]

PYLORIC STENOSIS OF INFANTS

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1. AETIOLOGY AND PATHOLOGY

Gross pyloric hypertrophy

283] This disorder occurs predominantly in first-born male infants, its incidence in males being five times more frequent than in female infants. The essential pathological feature is a gross hypertrophy of the musculature of the pyloric canal, ending abruptly at the pylorus but fading away gradually at the proximal end (Fig. 131). The hypertrophy, which is a true hyperplasia, is most obvious in the circular coat, but as Stiles observed in dissected specimens, the degree of hypertrophy may be relatively greater still in the longitudinal layer (quoted by Cunningham, 1906).

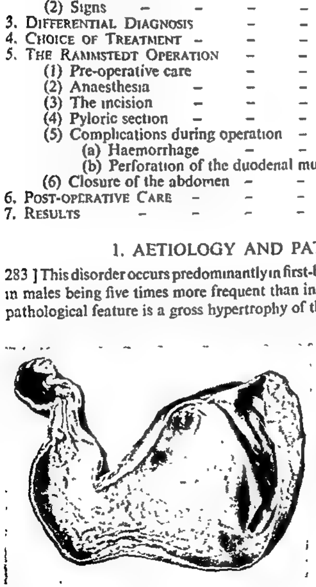

Fig 131 —Specimen from the Museum of the Hospital for Sick Children, Great Ormond Street. Note the mucosal fold, partially blocking the pyloric canal and the relation of the duodenal lumen

Dilatation of the stomach and some degree of gastritis due to retention result from the obstruction, and the mucosa,

particularly in the pyloric region, becomes oedematous and folded, thus blocking the lumen still further.

It is generally believed that the hypertrophy is compensatory—an attempt to overcome an inherent inability of the pylorus to function normally, by reason of a neuro-muscular incoordination (achalasia). Doubtless the fundamental disorder is congenital, but there is some evidence that the hypertrophy is a post-natal development. *Pathogenesis*

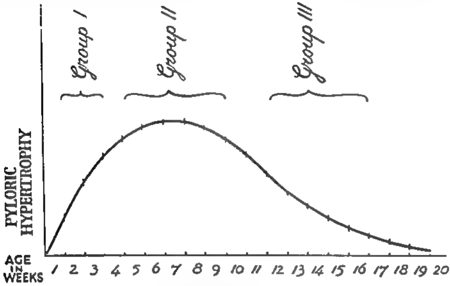

FIG. 132.—Curve showing incidence of pyloric hypertrophy in infants divided into groups according to age.

Observations made at the time of operation enable the cases to be divided into three groups (Fig 132).

(1) Group I

Infants who are operated on up to the third week from birth comprise this category, the earliest case, in the writer's experience, being at the ninth day. Clinically the pyloric tumour is small and elusive. At operation it is found to be soft and vascular; though it cuts easily, the texture is loose and the bleeding free. The extent of the hypertrophy is obviously much less than that seen in the later cases, and the appearance suggests, rather, a developing stage with rapid growth and great vascularity.

(2) Group II

Infants operated on between the fourth and ninth weeks comprise the great majority of cases Clinically the tumour is readily palpable and at operation it is found to be large, firm and avascular. The muscle is very thick, cuts cleanly, and the cut surface is pale and bleeds but little. The appearance suggests hypertrophy at its height—muscle bundles packed tightly and blood-vessels squeezed out; auto-devascularization determining atrophy and resolution.

(3) Group III

This group comprises cases operated on between the third and fourth month of life. At operation the tumour is still large but it has become leathery in consistence. It cuts with some difficulty and bleeds more freely than at any other stage. The muscle tends to adhere to the mucosa and considerable separation may be necessary to free the mucosa adequately. The appearance indicates resolution. We know that in cases in which recovery is complete all traces of the hypertrophy usually disappear.

Role of neuro-muscular incoordination

This grouping seems to indicate that the disorder proceeds in a definite cycle in which hyperplasia reaches a maximum, and then subsides as natural recovery ensues. The inference is that a better understanding of neuro-muscular incoordination may well provide us with the clue to the prevention of the hypertrophy.

2. CLINICAL FEATURES

The onset is commonest between the second and the fourth week. Occasionally it is earlier and may date from birth; on the other hand, it may be as late as the fourth month.

(1) Symptoms

Vomiting

Premonitory symptoms may be discomfort after feeds, constipation, or even a slight rise of temperature, but usually the initial incident is vomiting. A virile infant, whose previous progress has been exemplary, regurgitates a feed without warning. This unlooked-for phenomenon recurs, and the vomiting soon

FIG. 133.—Showing peristaltic wave passing from left to right.

Bile usually absent from vomitus

becomes forcible. Some feeds are retained, but from time to time a single large projectile vomit occurs which is clearly cumulative, being made up of the undigested residue of several previous feeds. The vomitus contains mucus and, occasionally, a streak of blood. Bile is said to be unknown, but it has been noted on rare occasions when the symptoms have begun in the first week of life. Despite the vomiting the infant becomes hungry and takes his feeds

with avidity, but constipation, oliguria, dehydration and loss of weight ensue in proportion to the severity of the vomiting.

(2) Signs

The confirmatory physical signs are well-marked visible gastric peristalsis and palpation of the pyloric tumour (Fig. 133). The infant's abdomen should be examined during, and immediately after, a feed. If necessary a feed of glucose water is given. The examination is made in a warm atmosphere and in a good light. The baby is exposed as indicated in Fig. 134, and the observer palpates the abdomen with the warmed left hand. The tumour is sought for below the liver, to the right of the midline. It varies in position and may be *Examination of abdomen*

FIG. 134.—Palpation of the pylorus.

obscured by the liver. The pylorus hardens and softens, especially in the early case, and it may be palpable only in systole, a phase which commonly heralds a vomit. Repeated examinations, therefore, may be necessary before it is finally felt.

3. DIFFERENTIAL DIAGNOSIS

tumour not felt before operation; 3 of these infants were boys, 3 were girls. In the 3 boys true hypertrophic stenosis was found at operation; in the 3 girls it was not. Vomiting in early infancy may arise from feeding difficulties, from the swallowing of air, or even as a result of intracranial birth injury, but in all *Other causes of vomiting*

these cases the vomiting is irregular in its incidence and the clinical picture lacks precision. Vigorous peristalsis is not seen and a tumour is not present.

In duodenal obstruction due to stenosis, atresia, adventitious bands or mesenteric root ileus, the vomiting dates from birth and the vomitus contains bile. Though gastric dilatation and peristalsis are present, a tumour cannot be felt.

Barium feed

In doubtful circumstances a barium feed may be helpful in diagnosis, but in true pyloric stenosis it is rarely necessary. In duodenal obstruction, on the other hand, radiological evidence is invaluable.

4. CHOICE OF TREATMENT

General considerations

The treatment of choice is still surgical. A well-ordered early operation offers the prospect of cure in approximately 2 weeks to 98 per cent of these infants. Statistics of non-operative treatment cannot, as yet, fairly compare with that figure, though doubtless this may not always be so. In recent years with the aid of Eumydrin (atropine methylnitrate) a considerable measure of success has been achieved by non-operative methods, but at best the period of treatment is prolonged and the infant's gradual recovery may well be attended by considerable risk and anxiety.

Indications for operation

Operation is imperative when the vomiting is severe and the infant is dehydrated, perhaps febrile, and losing weight. If medical treatment is to be considered, it should be only in the milder cases in which the vomiting is less persistent, dehydration is not serious, the weight is being maintained, and there is a daily stool of reasonable bulk, all indicating that some food is passing through the pylorus. The danger is that, if a relapse occurs and a late operation becomes necessary, the operative risk will certainly be increased.

Eumydrin

Eumydrin is best administered as a freshly prepared solution (1 in 10,000) in doses of 3–5 millilitres, given by mouth 20 minutes before a feed. When the drug is vomited, lamellae of Pyloroplastin may be placed under the tongue, though this measure is less reliable. The administration must be continued for several weeks or even months. In the early stages gastric lavage is carried out until vomiting ceases.

Gastric lavage

Risk of gastro-intestinal and respiratory infection

The real danger to all these infants lies in the risk of gastro-intestinal and respiratory infection. Efficient "barrier nursing" and, if the infant is in hospital, cubicle isolation are essential.

If the decision to operate is made, the mother should remain with her baby, and it is important that she should be encouraged to resume responsibility as soon after the operation as possible, so that she may have confidence in herself and her child. Breast feeding, if already established, should be maintained at all costs. In cases in which the operation is undertaken in hospital, the infant can usually be sent home safely on the fourth or fifth day, to return, if need be, for the removal of the stitches.

5. THE RAMMSTEDT OPERATION

Although skilled and devoted nursing care are essential in the successful management of these infants, perfection of surgical achievement equally demands the closest attention to detail in regard to the preparation for operation, delicacy of handling and complete haemostasis during operation, and meticulous after-care.

(1) Pre-operative care

The baby's general condition is the guide to its needs. Replacement of fluid is called for in proportion to the degree of dehydration present. If the infant's condition is exceptionally good, the parenteral administration of fluids may be dispensed with altogether. It is usually best, however, to infuse 8–12 ounces of 5 per cent glucose-saline solution into the axillae or thighs during the 24 hours prior to operation. *Fluid replacement*

If dehydration is severe, with urine chlorides low or absent, a continuous intravenous drip should be established, and operation postponed until the general condition is adequately restored. Examination of the urine for chloride is a simple guide but estimation of blood chloride is more reliable. If the reading is below 600 milligrams per 100 cubic centimetres, operation is delayed. *Estimation of blood chloride*

The infant requires a total fluid intake of approximately 2½ ounces per pound of body-weight per 24 hours. In the feeblest infants, a blood transfusion may be a life-saving measure. The quantity given should not exceed 10 cubic centimetres per pound of body-weight. Special attention should be given to keeping the baby warm, particularly during the operation and the recovery period, but the possibility of inducing hyperpyrexia by over-heating must be borne in mind.

It is usually wise to wash out the stomach, using sterile water or normal saline solution, once or twice in the 24 hours before operation, to rid the stomach of excess of mucus and of stagnant food. *Stomach wash-out*

(2) Anaesthesia

The writer's preference is for a general anaesthetic, a mixture of nitrous oxide, oxygen and ether being the best. In skilled hands it affords the requisite relaxation with the minimum of risk. Ether alone is the alternative.

The use of atropine pre-operatively is best avoided, as it appears to increase the risk of post-operative hyperpyrexia. Local anaesthesia is extensively used, and is usually very satisfactory, but in a restless baby there is a risk of prolapse of intestine, which adds to the shock and makes closure of the abdomen troublesome. A pre-operative dose of chloral hydrate (from 2 to 3 grains), the use of Denis Browne's "crucifix", and deflation of the stomach by the passage of an oesophageal tube at operation, all are helpful. *Pre-operative atropine contra-indicated* *Useful measures*

The skin and rectus sheath must be widely infiltrated. A suitable solution is that of Novocain-Suprarenin 0.5 per cent. This contains: Novocain 0·5 per cent, Suprarenin 0.0005 per cent, sodium chloride 0.7 per cent, with a small quantity of phenylmercuric acetate as preservative, in distilled water.

(3) The incision

The *incision is made vertically, to the right of the middle line*, beginning at the costal margin and extending downwards for approximately 2 inches (Fig. 135). The liver lies subjacent to the upper part of this high incision and its presence facilitates closure. Some surgeons prefer a midline incision; this avoids splitting the rectus but tends to weaken the scar. The oblique incision, parallel to the rib margin, advocated by others, gives less direct access to the pylorus. Any bleeding points having been clipped, and ligated if necessary, and the skin guards adjusted, the rectus muscle is split and the peritoneum *Assessment of value of various incisions*

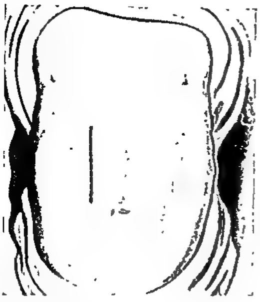

FIG. 135.—The abdominal incision.

exposed, the liver shining darkly through it in the upper part of the wound.

Minimization of shock and risk of prolapse

The peritoneum is opened and the pylorus gently withdrawn, with enough stomach to give the assistant a comfortable purchase. At this stage a very distended stomach may cause some embarrassment; if so, it should be deflated by the passage of a stomach tube. This manoeuvre helps considerably to reduce the risk of prolapse and added shock. If necessary, the intestines are retained by a narrow gauze pack introduced at the lower end of the wound.

(4) Pyloric section

While the assistant holds the stomach with the left hand, the operator fixes the pylorus with the left finger and thumb, and proceeds to incise it along the

FIG. 136.—The pylorus delivered into the wound. Note the "bloodless line" on the antero-superior aspect

"bloodless line" on the antero-superior aspect (Fig. 136). The incision is begun with a clean knife, cutting through the peritoneum and just entering the muscle layer. It is then completed with any suitable blunt instrument,

proceeding with care until the mucosa bulges into view. The muscle edges are then undermined and widely separated, using a pair of blunt-nosed artery forceps or Denis Browne's "spreader", *until the mucosa bulges fully.* The

FIG. 137.—Manoeuvre to assist completion of the section at the duodenal end.

FIG. 138.—The section completed. Note the wide *separation and the bulging mucosa.*

gastric end presents no difficulty, the thickened muscle thinning away gradually. The pyloric end, however, is less easy; complete division here must be ensured, and the possibility of perforating the duodenal mucosa must be borne in mind. It will be found helpful to stretch the incision widely with artery forceps in order to put any remaining undivided bands on the stretch, splitting them by careful blunt dissection (Figs. 137 and 138). A small but very constant vessel, the pyloric vein, bleeds conveniently when the correct point has been reached. Persistence of vomiting after operation usually means that section at the pyloric end has been incomplete.

Danger of perforation of duodenal mucosa

Sign of incomplete section

(5) Complications during operation

(a) *Haemorrhage*

In the vast majority of cases haemorrhage is negligible. Occasionally a small vessel may need to be clipped. If necessary, it can be underrun with fine catgut on an atraumatic needle.

(b) *Perforation of the duodenal mucosa*

This mishap is serious only because it may pass unnoticed. A tell-tale bubble or two gives the only clue to its presence. When it has occurred the hole must be closed by a fine catgut suture and is best reinforced by a muscle-graft seal In the writer's experience of three such accidents, one infant died and two survived.

(6) Closure of the abdomen

The peritoneum and rectus sheath are closed by two layers of continuous catgut Two tension skin-sutures include the anterior layer of the rectus sheath, and finally the skin edges are apposed by a subcuticular stitch which, in contrast to clips, has the advantage of easy removal.

6. POST-OPERATIVE CARE

Oxygen and Coramine for collapse

Following operation, the baby should be closely watched for some hours and kept warm but not "cooked". Collapse would call for oxygen and an appropriate dose of Coramine Restlessness is unusual, but if it is marked it may be overcome by giving a small dose (2 grains) of chloral hydrate.

The temperature should be taken at frequent intervals, for these infants are subject to attacks of pyrexia, a condition which may determine a convulsion and have serious consequences It is less often seen nowadays, thanks to earlier diagnosis and a better understanding of the means of preventing dehydration. The use of atropine pre-operatively appears to predispose to this complication. Should the temperature rise to 102° F., an icebag should be used to cool the baby down.

Feeding

In the post-operative period, feeding is, of course, the really important feature. Schedules vary in minor details, that employed by the writer is shown in the Table.

Disappearance of visible peristalsis

It is unusual for the baby to vomit again after the operation. The visible peristalsis disappears by the second to third week after operation. The bowels begin to act normally again by the third or fourth day and the weight begins to rise by the end of the first week.

The stitches are removed on the eighth day, an Elastoplast "corset" being worn for a further 2 weeks.

TABLE

SCHEDULE OF FEEDING IN THE POST-OPERATIVE PERIOD

NUMBER OF HOURS AFTER OPERATION	AMOUNT	ARTIFICIAL FEEDING	BREAST FEEDING
4	2 drachms	Half-strength Hartmann's* solution	Half-strength Hartmann's solution
6	2 drachms	Half-strength Hartmann's solution	Half-strength Hartmann's solution
8	2 drachms	Ordinary milk feed	Breast milk
10	4 drachms	Half-strength Hartmann's solution	Half-strength Hartmann's solution
12	4 drachms	Milk feed	Breast milk
14	6 drachms	Half-strength Hartmann's solution	Half-strength Hartmann's solution
16	[illegible] drachms	Milk feed	Breast milk
18	1 ounce	Half-strength Hartmann's solution	Half-strength Hartmann's solution
20	1 ounce	Milk feed	Breast milk
22	1 ounce 2 drachms	Half-strength Hartmann's solution	Half-strength Hartmann's solution
24	1 ounce 2 drachms	Milk feed	Breast milk
26	1 ounce 4 drachms	Half-strength Hartmann's solution	Half-strength Hartmann's solution
28	1 ounce 4 drachms	Milk feed	Breast milk
30	1 ounce 6 drachms	Half-strength Hartmann's solution	Half-strength Hartmann's solution
32	1 ounce 6 drachms	Milk feed	Breast milk
34	2 ounces	Half-strength Hartmann's solution	Half-strength Hartmann's solution
36	2 ounces	Milk feed	Breast milk
[illegible]	2 ounces 2 drachms	Milk feed	Breast feeding
42	2 ounces 4 drachms	Milk feed	
46	2 ounces 6 drachms	Milk feed	
50	3 ounces	Milk feed	
54	3½ ounces	Milk feed	
58	4 ounces	Milk feed	

* *Hartmann's solution (synonym lactated Ringer's solution).* A solution containing, in each 100 cubic centimetres: 20 milligrams calcium chloride, 30 milligrams potassium chloride, 600 milligrams sodium chloride and 310 milligrams sodium lactate

7. RESULTS

A year's experience in the surgical service at the Hospital for Sick Children, Great Ormond Street, may be quoted.

Between October, 1946 and November, 1947, 200 Rammstedt operations were performed; 3 deaths occurred.

The anaesthetics employed were: general 45, and local 155. The fatalities were due to: (1) subphrenic abscess following perforation at operation; (2) gastro-enteritis developing after discharge home; (3) gastro-enteritis in an infant aged 3 months.

REFERENCES

Cunningham, [illegible] J (1906) *Trans roy. Soc. Edinb.*, 45, 9.

[References to other titles are given under Pyloric Stenosis of Infants in the Index Volume. The subject is also dealt with under the heading of Pyloric Obstruction in the *British Encyclopaedia of Medical Practice* (1938), Vol. 10, p. 426]

RABIES

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1. AETIOLOGY

284.] Rabies (synonyms. hydrophobia, *la rage*, lyssa, *Tollwut*) occurs in most countries primarily as an enzootic disease in the dog family and is transmitted by bites or licks. Most warm-blooded animals are susceptible Human beings are chiefly infected by dogs, but jackals, wolves and other animals such as the meerkat (South Africa) and the vampire bat (South America) also carry the infection.

Animals responsible

2. CLINICAL PICTURE

(1) Incubation period

Symptoms usually follow infection in from 20 to 60 days. Death has been known to occur in 11 days, and also to have been delayed for over a year. Such extremes are rare. The incubation period varies with the site of the bite The average periods for bites on the face are 30 days, the arm 40 days and the leg 60 days.

Variations according to site of bite

(2) Symptoms

Prodromal period

There is usually a prodromal period in which pain in the scar, malaise, headache, slight fever, restlessness and vague anxiety with phases of hurried breathing and rushing speech may occur.

Clinical course

The restlessness and discomfort increase, until the characteristic spasms supervene when an attempt to drink is made. The head is drawn back in spasmodic jerks accompanied by gasping respirations and violent spasms of the pharynx and larynx; the hands snatch at anything within reach and the chest remains fixed until the spasm subsides. Between attacks the patient is

quiet; his mind is clear. Later, the slightest stimulus may induce a spasm. The voice changes. The mouth is choked by thick mucus which is often ejected about the room. Terror may incite outbreaks of intense fury in ignorant patients. Vomiting is frequent, the temperature is raised and glycosuria may be present. Finally, the attacks may become more general and prolonged. *Termination* Death usually occurs in a spasm, between the second and the fourth day. If the patient survives, the spasms gradually abate. Extensive paralyses supervene, followed by coma and death.

The spasmodic stage may be slight or absent and the disease takes the form of a rapidly ascending myelitis, finally involving the muscles of respiration and deglutition. The patient remains conscious until shortly before death. Paralytic rabies rarely follows dog bites but is associated with the bites of *Paralytic rabies* vampire bats.

Symptoms in the dog

"Furious" and "dumb" forms are recognized. The animal shows a gradual change of temperament. It becomes morose and tends to hide in corners, or may become more affectionate. An abnormal appetite may lead it to swallow earth, stones or other objects. "Hydrophobia" is not a symptom in dogs. In the furious type the animal frequently becomes greatly excited, breaks loose and roams about biting everything in its way.

The paralytic stage follows. Paralysis of the vocal cords changes the character of the bark. Inability to swallow causes a flow of ropy saliva. The animal staggers and falls, as a result of increasing paralysis of the limbs Death occurs 3 or 4 days after the onset of symptoms.

In dumb rabies the furious stage is suppressed The dropped jaw and other paralyses are the chief symptoms.

3. PATHOLOGY

(1) The virus

The virus is a neurotropic filtrable virus. Pasteur showed that it was present in the brains of rabid animals and could be passaged to other animals by subdural inoculation with an incubation period of about 14 days (street *Street and fixed virus* virus) By continued subpassage the incubation period could be reduced to a minimum of about 7 days (fixed virus) In this process of fixation the virus lost its power of infecting by the subcutaneous route. The virus is implanted *Mode of infection and spread* in the tissues by the saliva, which may be infective for 3 days before symptoms appear in the dog. It travels along the nerves to the central nervous system. The blood and lymphatics play little part in its spread.

(2) Morbid anatomy

The post-mortem appearances present few characteristic features. There may be congestion of the throat and respiratory passages and of the membranes covering the brain The cerebrospinal fluid is increased. Microscopically, the *Microscopic appearances* blood-vessels of the brain are dilated, with infiltration of the perivascular spaces Groups of nerve cells show different stages of degeneration. In advanced cases Negri bodies are present in these cells (Fig. 139). Stained with *Negri bodies* Giemsa's, Mann's or other stains, they appear as round or oval bodies of varying size—the intracellular inclusions characteristic of a virus. They may also show internal structure—the "elementary bodies". Nerve cells of the

hippocampus major or the cerebellum in the dog show the bodies most distinctly. Their true significance is uncertain but they are present in over

FIG 139.—Negri bodies in the hippocampus major of a rabid dog. The "bodies" lie beside the large cell nuclei or in one of its processes. The cell on the left shows two small "bodies". The Negri body in the centre cell shows the characteristic "inner" bodies (× 1,000). *(From a preparation kindly lent by Colonel H E. Shortt, I.M.S.)*

90 per cent of street virus (not fixed virus) infections and, if found, prove infection. Their absence does not negative a diagnosis of rabies.

4. DIAGNOSIS

The history of exposure to biting infection, the long incubation period and the rapid development of the characteristic syndrome usually establish the diagnosis.

Hysteria, tetanus, Landry's disease, and, in tropical countries, datura poisoning may require consideration. In doubtful cases the presence of Negri bodies, found either directly or indirectly after animal inoculation, will decide the issue.

5. PROGNOSIS

Rate of infection

Once the disease has declared itself, death inevitably follows. Comparatively few animals or human beings, even if bitten by a rabid animal, ultimately develop the disease. The infectivity of rabid animals varies greatly in individual cases and according to the stage of the disease. No infections may follow in some instances; in others, especially in wolf bites, few may escape. In untreated human beings at risk, the mortality rate has been estimated at about 16 per cent.

Factors influencing infection

Certain factors influence the chances of infection. The risk increases with the number, depth and extent of the wounds and decreases with interposition of clothing, and with cauterization. The most dangerous site is the face, then the arm and then the leg.

6. TREATMENT

(1) Immediate treatment of the wound

Disinfection and cauterization

If seen immediately, the wound should be encouraged to bleed freely. Thorough disinfection should then be carried out, followed by cauterization with pure carbolic acid or a similar caustic. The smallest abrasions must be treated and each tooth-mark thoroughly probed. In extensive wounds of the face, when the application of caustics is inadvisable, thorough irrigation with 20 per cent soft soap in water is recommended (Shaughnessy and Zichis, 1943 and 1944). Complete excision of the wound has been practised. The subsequent treatment follows the usual procedure for infected wounds. Drugs, such as the sulphonamides, have not been shown to have any effect on the rabies virus—there is no specific drug treatment.

(2) Vaccine therapy

(*a*) *Indications for treatment*

All persons "at risk" should undergo anti-rabic treatment. The chances of infection must therefore receive careful consideration.

Biting animal alive

If the biting animal is alive, it must *not* be killed. It should be confined, and if it is alive after 10 days, the patient is free from risk.

If the animal dies within this period, the diagnosis should be verified, if necessary, by search for Negri bodies or by animal inoculation. If pathological assistance is not available on the spot, half of the animal's brain should be placed in rectified spirit or 10 per cent formalin for microscopic examination, and a small part, preferably the medulla, in 50 per cent glycerin and water for test inoculation. Both should then be dispatched immediately to the laboratory. Persons exposed to infection should then be advised to undergo treatment.

Biting animal lost or dead

In bites on the head or fingers or extensive bites elsewhere, treatment *must* be begun immediately and discontinued when it is proved to be unnecessary. If the animal has escaped or has been killed, treatment should be advised.

Licks

The virus cannot pass through unbroken skin, but saliva can infect through fresh abrasions and mucous surfaces.

FIG. 140.—Male, aged 6 years, bitten by a dog which inflicted 2 wounds on the thigh. Died from hydrophobia 32 days afterwards in spite of anti-rabic treatment.

(*b*) *Anti-rabic vaccines*

"Living" and "dead" vaccines

Anti-rabic vaccines consist of suspensions of brain or spinal cord from a rabbit or sheep infected with fixed virus. Some vaccines contain living virus, attenuated by different means. In others, the virus is killed.

Pasteur's vaccine

Fig 141.—Male, aged 10 years, bitten by a dog which inflicted 4 deep wounds on the face, 3 of which were extensive. Anti-rabic treatment was successful.

Pasteur's original treatment belongs to the former group. Rabbits' cords are dried over potassium hydroxide for periods ranging between 14 and 3 days. The injections begin with "14-day" cords and increase in strength until "3-day" cords are used. This method is still in use in France and many of her dependencies.

Semple's vaccine

Semple's carbolized vaccine, containing killed virus, is now widely employed and can be safely distributed to outside centres. In India, where a 5 per cent suspension of sheep's brain is used, the dosage is as given in the following Table.

Classification of Patients and Dosage

	Class of Case		Daily Dose of Vaccine (in millilitres)	Duration of Treatment (in days)
I	Licks on fresh abrasions and mucous surfaces		2	7
II	Small bites, licks and scratches on fingers		5	14
III	All licks and bites on head and neck Multiple and extensive bites elsewhere All wolf and jackal bites	Adults	10	14
		Children	5	14

Precautions during treatment

During the treatment no alcohol should be allowed and excessive exercise should be avoided.

Results

The mortality rates for treated cases, collected for many years from a large number of Pasteur Institutes, are, according to Greenwood (1945-46) 0·32 per cent (Europeans 0·15, non-Europeans 0·52) (Figs. 140 and 141).

(3) Sequelae

Patients may complain of transient headaches or giddiness during the treatment. Erythematous patches and urticaria may arise from about the seventh day onwards. A very rare development, which occurs more frequently when "living virus" vaccines are used, is the "paralytic accident". This takes the form of an affection of the cranial nerves, a paresis of the lower limbs, an involvement of the autonomic nervous system, or, in severe cases, a dorso-lumbar myelitis or paralysis of the Landry type.

(4) Treatment of hydrophobia

Treatment can only be directed towards the alleviation of the many distressing symptoms. The patient should be placed in a darkened room in quiet surroundings. Chloroform inhalations, morphine and especially atropine help to relieve the violent spasms. Hypodermic injections of curare may also be tried. When swallowing becomes difficult, rectal infusions will relieve thirst and supply nutriment. Chemotherapy has not yet been of any avail.

7. PREVENTION

In countries where rabies is unknown its admission can be prevented by strict quarantine of imported animals. Where the disease is endemic and threatens to increase unduly, the dog population should be reduced by the destruction of stray animals and the control of all owned dogs. Vaccine treatment of dogs, both as a prophylactic and a curative measure, is now practised in many countries. Prophylactic immunization can be recommended, but if a dog has been bitten by a known rabid animal the safest course is to destroy it at once.

BIBLIOGRAPHY AND REFERENCES

Cunningham, J., Malone, R. H , and Craighead, A C. (1933) *Ind. med. Res. Mem* , No 26.

Galloway, I. A (1943–46) *Trop. Dis. Bull* Rabies; reviews of recent articles.

Greenwood, M (1945–46) *Quart. Bull. Health Org L.o.N.*, 12, 301.

Harvey, W. F., and McKendrick, A G. (1923) *Practice of Medicine in the Tropics*, Vol. 3, p. 2197. Ed. by W. Byam and R. G. Archibald. London; Oxford University Press.

Johnston, H N. (1945). *Proc Ann Mtg U.S Livestock Sanit Ass.*, p. 99.

— (1947). *Ann N.Y. Acad Sci.*, 48, 361.

McKendrick, A G. (1924–43). *Trop. Dis. Bull.* Rabies; reviews of recent articles.

National Research Council (1946). *J Amer vet. Med Ass* 108, 293.

Pawan, J. L (1939) *Ann. trop. Med. Parasit.*, 33, 21.

— (1939). *Trop. Dis Bull* , 36, 726

Price, F. W. (1946) *Text Book of the Practice of Medicine*, 7th ed , p 1616. London; Oxford University Press.

Rhodes, A J. (1946). *Trop Dis Bull* , 43, 975.

Shaughnessy, H J., and Zichis, J. (1943) *J. Amer med Ass.*, 123, 528

— — (1944) *Trop Dis. Bull.*, 41, 173.

Shortt, H E (1935). *Ind J. med. Res.*, 23, 407.

— Malone, R. H., Craighead, A. C , and McGuire, J P. (1934). *Ind. med Res Mem* , No 28.

Syman, P. S (1940) *Onderstepoort J. vet Sci.*, 15, 9

— (1942) *Trop. Dis. Bull* , 39, 86.

Van Rooyen, C. E., and Rhodes, A. J. (1940). *Virus Diseases of Man*, p 637. London , Oxford University Press.

Webster, L. T. (1939). *Amer. J. Hyg.*, (*Sect. B.*), 30, 113.

Webster, W. J. (1944). *Rabies and Antirabic Treatment in India* Simla; Government of India Press

Wilson, G. S , and Myles, A. A (1946) In *Principles of Bacteriology and Immunity*, 3rd ed., p 1935 Ed. by W. W. C. Topley and G. S. Wilson. London; Arnold.

[References to other titles are given under Rabies in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol. 10, p. 446]

RADIO-ACTIVE ISOTOPES

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1. INTRODUCTION

285.] The atom is the smallest particle of matter which is characteristic of those substances called chemical elements. An atom consists of a positively charged core or nucleus, surrounded by an electron cloud, which carries an equal negative charge. The nucleus is built up of positively charged particles called protons and uncharged particles called neutrons The number of protons or unit positive charges in the nucleus defines the element and is called the atomic number Atoms of the same element which have different numbers ... of

Most of the atoms existing in Nature are stable. The nuclei of the ... atoms are unstable and undergo spontaneous disintegration, losing energy in the form of ionizing radiation (*gamma* rays, *beta* rays and *alpha* rays). Such atoms are said to be radio-active, and radium, discovered by Becquerel, was the first to find use in medicine as a therapeutic agent.

In 1934, it was discovered that isotopes which did not exist in Nature could ... methods and that these ... oduced by cyclotrons, and though they have been applied medically ... since their discovery, their use has been limited by the quantities available and the variety of atoms produced. The discovery of the chain-reacting pile has made possible the production of a greater variety of radio-active atoms in quanti... certain isotopes must ... years, ... agnosis these substances have found increased use in medicine ... and therapy.

The chain-reacting pile

2. PHYSICAL CONSIDERATIONS

Before radio-active isotopes can safely be used in medicine, three of their physical properties must be known and their implications understood. *Physical properties of isotopes*

(1) The type of radiation

The type of radiation emitted is important in determining methods of measurement, in estimating dosage and in designing protective shielding. At the present time the radiations of medical interest are *gamma* rays and *beta* rays These radiations differ principally in their powers of penetration. The most energetic *beta* rays lose all of their energy within a few millimetres of tissue, whereas hard *gamma* rays may penetrate the entire thickness of the body without much loss of energy.

(2) The energy of radiation

The energy of the radiation emitted must also be known for the reasons mentioned above. The energy of *beta* rays and *gamma* rays is expressed in million electron volt units and tables of radio-active isotopes usually give maximum energies. This quantity is important in considering measurement and shielding (Seaborg, 1944). The calculation of dosage requires a knowledge of the average energy of the radiation (Marinelli, Brinckerhoff and Hine, 1947) For *beta* particles the average energy is roughly one-third of the maximum energy.

(3) The half-life of the isotope

The half-life of the isotope is a factor in determining the duration of the radiation in the case of internally administered radio-active materials, the variation of source-strength with time and the duration of tracer experiments especially when short-lived isotopes are used.

Radio-active nuclei disintegrate at a characteristic rate, which is dependent only on the isotope and the number of its atoms present. The time taken for half of the atoms in a given quantity of the radio-active isotope to disintegrate is known as the half-life. Since the number of atoms disintegrating per second determines the intensity of the radiation, quantities of such material are expressed not in units of weight but rather in amounts which contain a certain number of atoms disintegrating per second. The unit employed in this connexion is the curie, which is the amount of isotope undergoing $3{\cdot}7$ by 10^{10} disintegrations per second. (This definition of the curie is not the original one but has become adopted through common usage.) The millicurie and microcurie are more commonly used units in medical and biological work. *Disintegration of radio-active nuclei*

3 RESEARCH

The use of radio-active materials as tracers in medical and biological research is dependent on two assumptions. These are: (1) that the living cell does not distinguish between isotopes of the same chemical element, and (2) that the radiation emitted does not affect the processes to be studied.

These two considerations set the upper limit of the tracer dose. The lower limit is set by the sensitivity of the measuring instrument after allowing for dilution, excretion and radio-active decay. *Upper limit of tracer dose*

On the other hand, radio-active isotopes offer a number of advantages, as follows. (1) Sensitivity of measurement is several times greater than in the *Advantages in diagnostic use*

usual chemical methods. (2) Complicated and laborious chemical assays are replaced by relatively simple physical measurements. (3) The experimenter is able to follow the path taken by the actual tracer dose administered. (4) The amount of tracer is usually so small as not to increase significantly the amount of the element present in the organism, and thereby disturb the metabolic process to be studied.

The present literature covering tracer research is enormous. The study of intermediary mineral, fat, and carbohydrate metabolism represents one of the most active fields today (Kamen, 1947). There is little doubt that tracer applications of radio-active isotopes offer most promise for future advancement of our biological and medical knowledge.

4. DIAGNOSIS

The attempts which have been made to use radio-active materials in diagnosis apart from diagnostic x-ray and fluoroscopy, may be divided into three categories:

(1) Measurements *in vivo*

Radio-active sodium and radio-iodine

Measurements *in vivo* are obtained after administration of a tracer dose of the isotope. Radio-active sodium has been used in the investigations of circulatory disturbances such as Buerger's disease (Quimby, 1947). Radio-iodine has been given to determine the uptake of iodine by the thyroid gland (Reinhard, 1947). Isotopes used in this way must be *gamma* emitters so that the radiation will be detected by an instrument placed outside the body. Such measurements are difficult to interpret with any degree of accuracy since the isotope in other parts of the body will interfere with the detector. This necessitates the use of highly directional measuring equipment and the careful use of shielding. These directional detectors are of low sensitivity, requiring an increased tracer dose to give the desired result.

Directional detectors

(2) Measurements of body fluids

Measurements are made on body fluids such as blood and urine after administration of the isotope. In such cases measurement presents no particular problem. The diagnosis of thyroid disease in babies has been made by examination of the urine for administered radio-active iodine (Quimby, 1947)

(3) Investigation of respiratory and circulatory functions

Radio-active gases have been used to some extent in the investigation of the respiratory and circulatory functions.

Although the use of radio-active materials has gone ahead in biochemistry, the physiologists have not taken the same advantage of this powerful weapon. When this happens it can be expected that the diagnostic use of these materials will increase.

e of long-ed isotope ntra-licated

In using radio-active materials in diagnosis the smallest possible amount should be given and a long-lived isotope should never be used in case it should be fixed in the body and later give rise to harmful effects.

5. THERAPY

Radium and radon were the first radio-active materials to be used in therapy (Wilson, 1945). The new radio-active isotopes do not offer substitutes for

radium with a conveniently long half-life. The best *gamma* ray source is Co^{60} with a half-life of 5·3 years. They do, however, offer an interesting field of research for the experimental radiotherapist and the physicist interested in problems of dosimetry. Since radium is now a by-product of the uranium industry, and since methods of applying it clinically are well known, there seems to be little justification for replacing it at present.

Radium on account of its long half-life and because it remains fixed in bone, giving rise to long-term harmful effects, does not lend itself to internal administration Some of the new radio-active isotopes can be introduced into the body with beneficial effects in certain clinical conditions.

Phosphorus 32 has been used with some success in the treatment of polycythaemia vera. Palliative results have been obtained in the treatment of certain leukaemias and in multiple myeloma (Reinhard and his colleagues, 1946). *Phosphorus 32*

Iodine 131 has been used as inorganic iodide in diseases of the thyroid gland. Its use has been unsuccessful in the treatment of thyroid carcinoma except in rare cases (Seidlin, Marinelli and Oshry, 1946). Whether it replaces surgery, in the treatment of hyperthyroidism, is still doubtful. *Iodine 131*

Sheppard and his colleagues (1947) have used colloidal manganese and gold in treatment of malignant disease of the reticulo-endothelial system. This form of therapy shows promise and is still in the trial stage. *Colloidal manganese and gold*

These are the principal attempts to use internally administered radio-active material in the treatment of disease. The principle involved is one of selective irradiation by means of selective absorption. The hope is to irradiate the pathological tissue while sparing the normal cells.

The introduction of radio-active materials into the human body is not an *operation to be undertaken lightly, since once administered the radiation* cannot be turned off and there is no therapy for over-exposure. The use of long-lived isotopes or isotopes giving rise to long-lived daughter products must be avoided, since these may be localized in certain parts of the body and give rise to malignant tumours. *Danger of localization*

6. DOSIMETRY

The dosimetry of radium therapy is now well established. The dosimetry of the new radio-active isotopes, which lend themselves to internal administration and to external application in a great variety of forms, is still largely in the stage of development.

The amount of energy absorbed from the radiation field by the living tissue and the distribution of this absorbed energy must always be known as accurately as possible in any therapeutic procedure. This quantity depends on certain physical and biological factors. The physical factors involve a knowledge of the absolute amount of radio-active material in the source, the type of radiation emitted, the energy of the radiation and the half-life of the isotope. The last three quantities are to be found in the standard tables of isotopes. The absolute amount of radio-active material is extremely difficult to determine and the therapist must depend for this information on a well equipped standards laboratory. The hospital laboratory, however, must be in a position to make accurate comparisons with substandards and to identify radio-active isotopes by means of simple absorption and decay curves. *Physical factors*

Biological factors

The biological factors involve the distribution and excretion of the isotope administered. These are usually predetermined by administration of a known tracer dose. From these biological and physical data calculations of tissue dose and time of irradiation can usually be made (Marinelli, Quimby and Hine, 1948). In general, the clinical or research use of radio-active isotopes cannot be divorced from the aid of a competent physicist.

7. HEALTH AND CONTAMINATION

Over-exposure to ionizing radiation

Microcurie amounts of radio-active material carelessly used can be injurious to the health of the worker. It is well known that in the past radiologists, radiotherapists and radium-dial workers have suffered damage from over-exposure to ionizing radiation. Since the chain-reacting pile has increased very considerably the potential supply of radio-active isotopes, the hazard of over-exposure has similarly increased. Radio-active substances may cause ill effects when they enter the body by ingestion, inhalation or injection, in addition to over-exposure to radiation from without. Present knowledge does not permit the detection of minimal degrees of radiation damage. Reduction of the lymphocyte count is still the most widely accepted criterion of early over-exposure to radiation. This blood change is now looked upon as a late effect. There is no specific biological index of exposure at the levels now accepted as permissible (0 1 r of *beta* and *gamma* radiation per working day) (Morgan, 1947). Physical measurement either by means of a photographic film or a condenser ionization chamber is therefore used to check the exposure of personnel to radiation. Experience has shown that these low permissible levels of radiation exposure do not interfere with efficient work.

Avoidance of contamination during work

Shielding

Apart from the health aspect, it is important that workers be extremely careful to avoid contamination of measuring instruments and biological material when handling radio-active isotopes. The techniques of the bacteriologist who handles pathogenic organisms could be used to advantage here. The levels at which contamination becomes serious are far lower than those at which health hazards appear. In general, good contamination control is good health practice but adequate shielding must still be provided against penetrating radiation.

8. FUTURE USES OF RADIO-ACTIVE ISOTOPES

Application of tracer techniques

The most profitable use of radio-active isotopes in the immediate future will probably be in the application of tracer techniques to research and diagnostic problems. In the therapeutic field the new materials offer many advantages [illegible] must be expected [illegible] wledge of the [illegible] led. A physical picture of the interaction of ionizing radiation with the atoms and molecules of the body has been built up (Lea, 1946). The clinical effects due to exposure to radiation are well known. Until some light is shed on the intermediate chemical and metabolic changes, radiation therapy will continue on an [illegible] tively. An understanding of the mechanism of action of ionizing [illegible] might also lead to methods of detecting minimal radiation damage and to

Intermediate chemical and metabolic changes

therapeutic measures for treating the effects of over-exposure, both important considerations in a world in which the amount of available radio-active material has suddenly increased so greatly.

REFERENCES

Hahn, P. F, and Sheppard, C W. (1948). *Ann intern. Med*, **28**, 598

Kamen, M. D (1947) *Radioactive Tracers in Biology*. New York; Academy Press.

Lea, D. E. (1946). *Actions of Radiations on Living Cells* London; Cambridge University Press

Marinelli, L. D, Brinckerhoff, R. F, and Hine, G. J (1947) *Rev. mod. Phys*, **19**, 25.

— Quimby, Edith H., and Hine, G. J (1948) *Amer. J. Roentgenol*, **59**, 260

Mitchell, J. S. (1946) *Brit J. Radiol*, **19**, 481.

Morgan, K. Z (1947) *J Phys colloid Chem.*, **51**, 984

Pollard, E, and Davidson, W. L. (1942) *Applied Nuclear Physics* New York and London; Chapman & Hall

Quimby, Edith H. (1947) *Amer. J Roentgenol.*, **58**, 741

— and McCune, D J. (1947) *Radiology*, **49**, 201

Reinhard, E. H. (1947) *Amer. J Roentgenol*, **58**, 757.

— Moore, C V, Bierbaum, Olga S, Moore, S, and Kamen, M D (1946). *J Lab clin. Med*, **31**, 107.

Seaborg, G T (1944) *Rev mod. Phys*, **16**, 1.

Seidlin, S. M, Marinelli, L D, and Oshry, E (1946). *J Amer med Ass*, **132**, 838.

Sheppard, C. W., Wells, E. B, Hahn, P. F, and Goodell, J P. B. (1947) *J. Lab clin Med*, **32**, 274

Smyth, H D (1945) *Atomic Energy General account of development of methods of using atomic energy for military purposes under auspices of U.S Govt.* 1940–45 Reprint of official U.S A. government publication London; H.M Stationery Office

Wilson, C. W. (1945) *Radium Therapy Its Physical Aspects*. London; Chapman & Hall

[References to other titles are given under Radio-active Isotopes in the Index Volume.]

RADIOTHERAPY

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1. DEFINITION

286.] Radiation is a process of transferring energy from one place to another. Radiotherapy, in this context, is the application of energy from certain types of ionizing radiations to living tissues as a means of combating disease. This method of treatment is employed for a wide variety of conditions but

predominantly for certain types of tumour, for certain infections and to reduce or alter glandular secretion. The radiations employed are x-rays, *gamma* rays, *alpha* rays, *beta* rays and neutrons; it is possible that protons may also be used in the future.

2. SOURCES OF RADIATION

X-rays are obtained from an evacuated glass tube (Fig. 142) containing a heated filament (the cathode) and a metal target (the anode). A high electrical potential is maintained across the tube so that electrons from the cathode are *Production of x-rays*

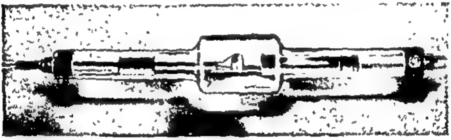


FIG 142.—220-kV Victor x-ray therapy tube

speeded across a gap to strike the anode, where their *energy of motion* is transformed into electromagnetic energy (x-rays). *Alpha, beta* and *gamma* rays are emitted spontaneously from some elements of high atomic number with complicated nuclear structure (for example uranium, thorium and radium) undergoing disintegration. *Alpha* and *beta* rays are electrically charged particles. As emitted spontaneously from radio-active substances, they have little power of penetration in tissues; as a result they are seldom used in treatment and then only for the most superficial lesions. The *gamma* rays are more penetrating; they are electromagnetic radiations (waves), identical with x-rays produced over a limited range of high electrical potential in the region of 1–5 million volts. *Spontaneous radio-activity* *An atom is composed of a nucleus which is positively charged*, surrounded by a number of negatively charged electrons. The atomic nucleus is exceedingly small and most of the atom is empty space. Since electrons have a very small mass nearly the whole weight of the atom is concentrated in the nucleus. The charge on the nucleus is equal to the number of electrons around it, for the atom as a whole is electrically neutral. The hydrogen nucleus has one unit of charge, and the uranium nucleus has 92 units Each element has its characteristic nuclear charge and therefore its characteristic number of electrons in each atom The atomic nucleus is composed essentially of two types of unit having approximately the same weight—protons which are positively charged, and neutrons with no electric charge. Atoms of the same element may therefore have different weights, for although the number of protons in the nucleus must be constant the number of neutrons can vary without altering the nuclear charge. Almost every element has atoms of different weights; these are known as isotopes of that element. Hydrogen, for example, has three isotopes H^1, H^2 (deuterium) and H^3 (tritium), and uranium a number of isotopes, two important ones being U^{238} and U^{235} the nuclei of which weigh approximately 238 and 235 times the weight of the light isotope of hydrogen. *Atomic structure* *Isotopes*
Radio-activity is the emission of radiation from the nucleus. Radium emits

particles carrying two positive charges (*alpha* particles), so changing from a solid metal into a gas (radon) with a nuclear charge two units less than that of radium. *Beta* rays emitted from the nuclei of other radio-active elements are electrons with little weight but with a negative charge. The nucleus that emits an electron thus gains one unit of positive charge without materially changing the weight of the atom. *Some radio-active elements disintegrate* rapidly, others slowly; the rate is expressed as the time it would take for half the atoms initially present to disintegrate. This half-life, or half-value period, is very variable (from a few microseconds to many hundreds of years), being 1,650 years for radium and 3·82 days for radon.

Half-value period

Artificial radio-activity

With special apparatus, such as a cyclotron, or a chain-reacting uranium pile, *it is possible to bombard atoms with certain particles which will enter* their nuclei, giving them excess energy and making them unstable. Neutrons are commonly used for this bombardment because they have no charge and so do not interact with the electric field of the nucleus, and can therefore penetrate it more easily. When atoms are bombarded by neutrons which penetrate their nuclei they gain energy and may become unstable. Unstable *atoms tend to revert to a stable state by giving off the energy gained in the* form of radiation (waves or particles). This process is the artificial induction

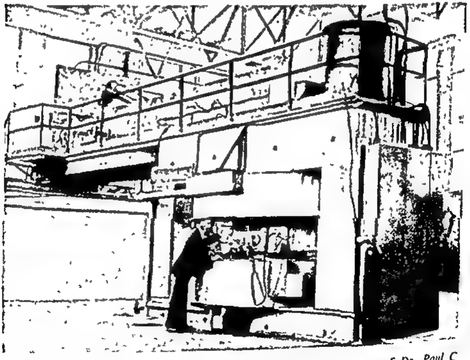


FIG. 143.—Lawrence's 60-inch, 220-ton cyclotron. *(By courtesy of Dr Paul C Aebersold and the Editor of "Radiology".)*

of radio-activity, and such unstable atoms are known as radio-active isotopes. Almost all elements can now be produced in radio-active form and some of these are of value in medical research and treatment.

Cyclotron

The cyclotron (Fig. 143) is an instrument designed to accelerate charged particles. The particles travel inside a *hollow* semicircular electrode, being accelerated each time that they pass in and out of the electrode on their spiral

orbits. These fast-moving particles are then allowed to strike a beryllium target from which neutrons are emitted. The neutron beam may either be used in treatment direct, or be employed in the production of artificially radio-active substances. *Neutron beam*

The pile consists essentially of blocks of a light element (often of pure graphite), into which a lattice of uranium metal rods is inserted. The uranium undergoes destruction by fission which liberates neutrons in a chain reaction producing x-rays, and *beta* rays secondarily. Stable isotopes can be inserted into the pile through special apertures for exposure to the neutrons so as to induce artificial radio-activity. In this way I^{131}, Na^{24}, P^{32} and other radio-active isotopes can be made. *Chain-reacting uranium pile*

New types of apparatus producing radiations suitable for use in treatment have been constructed. These instruments, the betatron (Fig. 144), the synchrotron and the linear accelerator, are designed to accelerate electrons which *Betatron, synchrotron and linear accelerator*

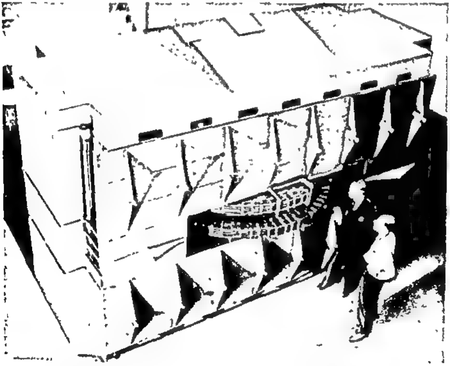


FIG 144 —100-million-volt betatron (*By courtesy of Victor X-ray Corporation.*)

are then used to produce x-rays at energies equivalent to those that would be produced by an x-ray tube operated at voltages up to 100 million. With an apparatus of this type marked biological effects can be produced at a depth in the tissues for small effects on the skin. This should prove to be a great advantage in the treatment of deep-seated tumours if the new problems and difficulties raised by this type of apparatus can be overcome.

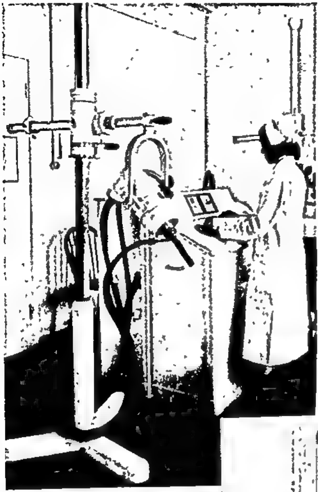
3. APPARATUS

The apparatus employed by the radiotherapist is becoming more varied and more complicated. X-ray therapy apparatus of different types and voltages is *X-ray apparatus*

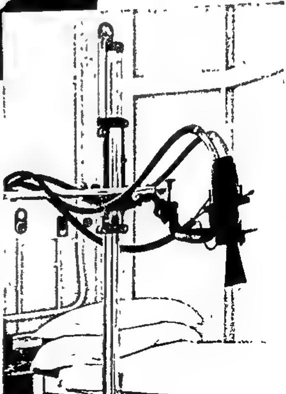
required for different purposes. The equipment varies from low-voltage x-ray plant for dermatology, for the treatment of superficial tumours and for some infections (usually 50–150 kilovolts) (Fig. 145), through moderate-voltage plants, on which most of the routine work is done (200–500 kilovolts) (Fig. 146), to high-voltage plants, for the more deep-seated tumours (1,000–5,000 kilovolts) (Fig. 147), and, with the new apparatus, on to an upper limit defined today for treatment more by problems of protection, buildings and safe and useful handling for patients than by technical difficulties.

Radium needles and tubes

Radium is packed into needles for direct insertion into the tissues, or on moulds for surface application, or into special capsules, tubes or boxes (Fig. 148) for intracavitary treatment. Radium may also be packed

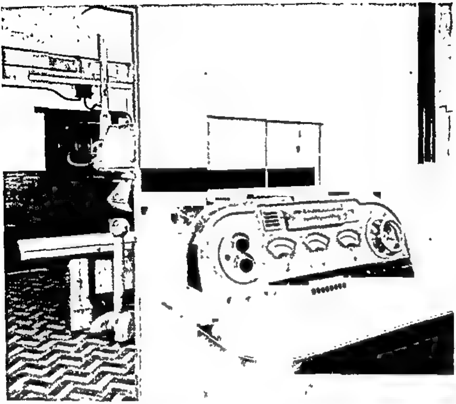


(*a*)



(*b*)

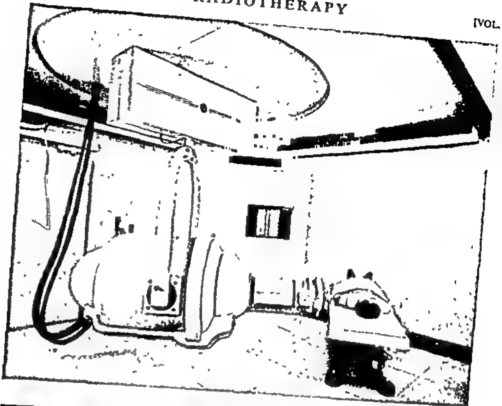
FIG. 145.—(*a*) 60-kV. short-distance low-voltage x-ray therapy apparatus (*by courtesy of the Editors of the "British Journal of Radiology"*); and (*b*) 60–140-kV Victor x-ray therapy apparatus.



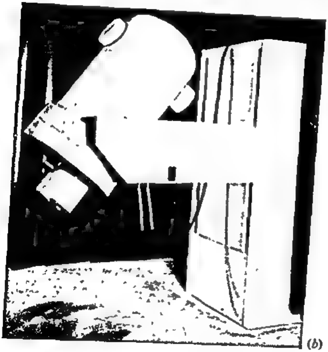
(a)

(b)

Fig 146—(a) 200-kV Watson x-ray therapy apparatus, and (b) 400-kV. Victor x-ray therapy apparatus



(a)



(b)

FIG 147.—(a) One-million-volt x-ray therapy apparatus (*by courtesy of Victor X-ray Corporation*); and (b) Two-million-volt x-ray therapy apparatus (*by courtesy of the High Voltage Engineering Corporation*).

Teleradium units

into larger units (5–10 or more grammes) known as teleradium units or "radium bombs" (Fig. 149), for use in much the same way as an x-ray tube.

Radon

[illegible]

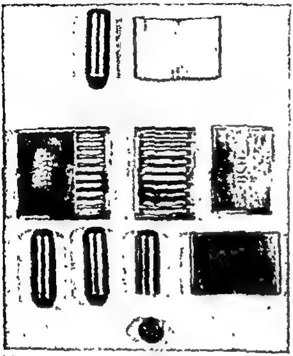
Cyclotrons, betatrons, synchrotrons, and linear accelerators

comparatively rapid rate of disintegration.

Cyclotrons, betatrons, synchrotrons and linear accelerators are not yet available for the treatment of patients in Great Britain, but are being acquired

for experimental clinical trial. Radio-active isotopes are being given by the mouth or by injection into the blood stream in the treatment of some generalized diseases, such as polycythaemia vera, leukaemia and the lymphadenopathies. They are of value in certain more localized conditions in which effective differential absorption can be obtained (for example, radio-active iodine for thyrotoxicosis), but it has not been possible as yet to obtain a sufficient concentration of these isotopes in the tissues where their effect is needed to give this method of treatment important therapeutic possibilities for cancer. Some radio-active isotopes will almost certainly be used in solid or liquid form either interstitially, or for surface applicators, or in mass units, or for insertion into body cavities such as the bladder and uterus. For

Radio-active isotopes



(a)

(b)

FIG. 148.—(a) Radium containers for intracavitary treatment (b) Radium capsules, tubes and boxes in the uterus and vagina.

this type of treatment they have, in fact, certain advantages over the naturally radio-active substances which have been used in the past.

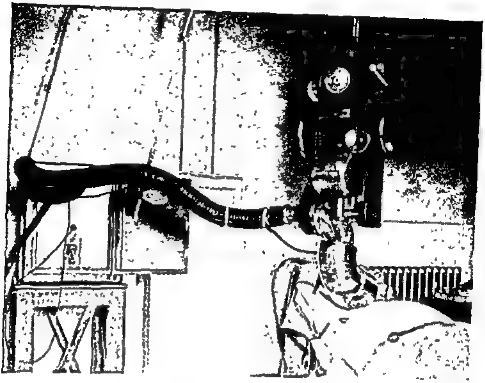


FIG 149 —Ten-gramme teleradium unit.

4. PHYSICAL BASIS OF RADIOTHERAPY

(1) Energy absorption

Ionization

When a beam of radiation is applied to a patient some of the energy is absorbed. Absorption takes place by the displacement of particles in the tissues through which the radiation passes. The ionizing particles for x-radiation and *gamma* radiation and for *beta* rays are electrons, for neutron radiation they are mainly protons, and for *alpha* radiation the *alpha* particles. A molecule deprived of an electron by this process is left positively charged and is called a positive ion, the electron ejected at great speed is the negative ion, and together they form an ion pair; this process is known as ionization. Ionization is the chief basis of the biological actions of the radiation. There is no evidence that any biological effect can be produced by one ionizing radiation that cannot be produced by another. The distribution of the ionization produced, however, varies with the type of radiation, so that one radiation may be more effective than another in producing a certain change. An electron torn from a molecule and passing through the tissues may possess sufficient energy to cause further ionization along its path. The amount of

Ion-density

ionization produced by electrons at each point varies with the rate at which ... greatest at the end of their

their mass (equal to that of the hydrogen atom and 1,800 times greater ...

that of the electron) These recoil atoms, mainly protons, the hydrogen nuclei, produce a high ion-density along their paths, for the energy of a proton is 1,800 times greater than that of an electron travelling at the same speed. *Alpha* particles are more densely ionizing still, for they have not only four times the mass of the proton but double the charge as well.

Excitation

Energy may be dissipated in the tissues by excitation (the raising of an electron in an atom to a state of high energy without its removal from the atom), as well as by ionization. Excitation of an atom through which an electron passes may be considerably more frequent than ionization, but what contribution this makes to the biological effect is at present unknown.

(2) Dose measurement

The unit of dose (r)

Definition of the roentgen (r)

A dose of radiation is the amount of energy absorbed at a given point. The basis of the measurement of dose is the ionization produced in air, and the unit of quantity of radiation is the roentgen (r). This unit was adopted as the international unit in 1928 and re-defined at the International Radiological Congress in 1937 for x-rays and *gamma* rays as follows. The roentgen shall be that quantity of x-radiation or *gamma* radiation such that the associated corpuscular emission per 0 001293 gramme of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign (0 001293 gramme is the weight of 1·0 cubic centimetre of dry air at normal temperature and pressure). The rate of energy absorption at a given place (the dosage rate) is usually given as r per hour or r per minute. Radiotherapy has been placed on a sound basis by the adoption of a physically well-defined unit of measurement of dose, and by the high degree of accuracy which has been achieved by the physicist in making these radiation measurements Ideally, energy absorption in tissues from beams of radiation would, if possible, be measured directly in ergs.

(3) Dose distribution

Distribution of dose

Using the roentgen, measurements of the dose received at a depth under a wide range of conditions have been made. Collaboration between radiotherapist and physicist in the estimation of the distribution of dose both for x-rays and radium throughout the volume irradiated has transformed radiotherapy in recent years and provided a precision hitherto unknown (Mayneord, 1932; Paterson and Parker, 1934, Honeyburne and her colleagues, 1939).

Physical system of dosage in radium treatment

The amount of radium required and the way in which it should be arranged in each individual case in order to give a prescribed dose homogeneously throughout a given volume of tissue, can now be determined accurately (Meredith, 1947). The employment of such a physical system of dosage forms an essential part of any radium treatment that is to conform to modern standards. The old ways of inserting a few needles into a tumour in a haphazard fashion, with no estimation of dose but merely a statement of the number of milligram-hours and no determination of dose distribution, have been abandoned by all who appreciate the advances that have been made. Such casual methods are quite unjustifiable today.

Three-dimensional dose distribution in x-ray treatment

In x-ray therapy the hospital physicist has often to deal with complex three-dimensional geometry and analysis, but a sound basis for delivering doses of radiation to the volume of tissue required has been established It is, in fact, now possible to deliver a prescribed dose to a given volume of tissue with a

degree of accuracy which has yet to be matched either by our ability to localize the volume to be treated or by an adequate knowledge of what dose should be given, or over what period of time the treatment should be spread.

5. BIOLOGICAL BASIS OF RADIOTHERAPY

(1) Possible modes of biological action

Ionization and biological action

It is possible that some biological effects of radiation are due directly to the ionization produced; when an atom is ionized the molecule concerned undergoes chemical change and it is probable that this forms the basis of most of the biological effects observed. Marked biological effects are produced by therapeutic doses of radiation, but very large doses have often been required in the past to produce measurable chemical changes *in vitro*. Dale (1942 and 1943) has shown that, under certain experimental conditions at least, when substances are irradiated in dilute aqueous solution the same weight of solute is changed per unit volume of solution whatever the concentration. It appears that the amount of solute changed depends on the number of ion pairs formed throughout the solution. The ionic yield is independent of the concentration of the solute because it is the solvent molecules which absorb the radiation and through them that energy is transferred to the solute. It is now clear that significant chemical changes can, under the right conditions, be produced *in vitro* by therapeutic doses.

Radiochemical reaction in dilute aqueous solution

Mode of action of radiation

The chief possible modes of action of radiation that have been investigated are the production of cell poisons, inactivation of enzymes, the direct ionization of large molecules in the cell and so possibly the inactivation of viruses, chromosome breakage, and the production of gene mutation (Lea, 1946). An excellent general review of the biological effects of penetrating radiations has been written by Spear (1946), and more detailed information is given by the British Institute of Radiology (1947).

(2) Basis of variation in response

Variation in response to irradiation

Irradiation of living tissues causes damage. The damage done depends on the amount and distribution of the dose, the dosage rate, the intervals between successive treatments, the number of treatments given and the total period of time over which the treatments are spread—that is, on the time–dose relationship. It also depends on the sensitivity of the different types of cell, the stage of mitotic activity and the duration of the mitotic cycle in individual cells—factors concerned with the inherent cell sensitivity. It further depends on the nature of the stroma and the state of the surrounding tissues—or more simply on the sensitivity due to environment.

(3) Direct effect on cells

Intracellular response

Therapeutic doses of radiation produce both temporary and permanent effects upon the cancer cell. The most important temporary effect is probably a delay in the onset of mitosis. Permanent effects are most clearly shown by chromosome breaks and death of cells, often following attempts at cell division, and by alterations in the proportions of cells in the growing portions of the tumour which are dividing, degenerating, resting or differentiating. These effects can be studied by serial biopsy of tumours in patients undergoing treatment; for instance, either by making a cytological analysis of

Chromosome breaks and degeneration of cells

alterations in division rate, the frequency with which cells in mitosis show radiation-induced changes in chromosomes, and the amount of damage done to single cells (Koller and Smithers, 1946); or by quantitative analysis of the proportion of the various cell types (dividing, degenerating, resting and differentiating) found in the young growing portions of the tumour at intervals during treatment (Glücksmann, 1941; Glücksmann and Spear, 1945). The promotion of differentiation by irradiation which now seems to be established is probably of great importance in treatment, the action on tumour cells being part destruction and part sterilization. The changes seen may be due to direct effects causing breaks in chromosomes, or lethal gene mutations produced by the passage of an ionizing particle, but it is probable that some of them at least are secondary effects due to chemical changes produced. Such chemical changes may be produced inside cells or inside enzymes for example, and radiochemical reactions are likely to be responsible for most of the biological effects of radiation that we observe.

Frequency and degree of chromosome damage

Changes in proportion of cells

Promotion of differentiation

Small doses of radiation have ■ beneficial effect in many inflammatory processes. They have also been found to hasten wound healing and to alter that disturbance of reparative growth in scars known as keloid. Freund (1947) considers that these comparatively small doses initiate repair, or control or prevent exuberant local reaction by the differentiating effect that they exert on mesenchymal cells which have such a marked inherent potentiality for metaplasia

(4) Indirect effect *via* stroma and tumour bed

The response of a tumour to irradiation depends as much upon the site at which it arises as upon its histological structure. Both the tumour bed, which is the environment in which the tumour grows, and the stroma, which is part of the tumour's own characteristic structure relatively slightly affected by site, play an important part in this response. It is important to study the effect of radiation on tumours in their normal biological environment. The differences in radiation effects on normal and on malignant cells are differences of rate and degree rather than of quality. With cell breakdown following irradiation widespread changes affecting the organization of the tumour appear, including disturbances of blood supply, the infiltration by white blood cells, the digestion and removal of debris and the formation of fibrous tissue. Subsequent irradiation cannot be expected to reproduce exactly the effects of the first exposure because the tissues being irradiated have changed. Tumours with different amounts and types of stroma will vary in their response just as much as tumours composed of different types of malignant cells. Response will vary with the presence and degree of infection and oedema. In fact, the effect of radiation on any given tumour will vary with a number of factors other than those concerned solely with the malignant cells which it contains. We need much more information on these indirect effects of radiation before we can clarify the problems of individual tumour response and determine accurately the factors governing radio-sensitivity and radio-resistance.

Intercellular response

Radiation effects on stroma and tumour bed

(5) Time–dose relationship

With some irreversible effects of radiation, such as the production of gene mutations, the change is independent of the time taken to give the dose or

Variation of response with dose, dosage rate, fractionation and total treatment period

the *quality of the radiation* and *only* depends on the amount of energy absorbed. With most of the changes taking place in tumours under irradiation, however, the *time factor* is of considerable importance. Variations in dosage rate (Gray, 1944; Koller, 1946), fractionation of the dose (dividing the treatment into a number of exposures and spacing these out over days or weeks), and the total time over which the whole course of treatment is spread have a profound effect upon the result obtained. These considerations are of importance both for the intracellular and intercellular reactions. Such variations of effect of dose with time can be studied in individual cases by means of serial biopsy or, more generally, by statistical analysis of the results obtained in groups of cases treated with varying time–dose relationships (Strandqvist, 1944).

6. RADIOTHERAPY FOR CANCER

(1) Curative and palliative treatment

Surgery and radiotherapy as curative agents

The fields of surgery and radiotherapy in the treatment of cancer are constantly changing with experience and the development of our knowledge, but are steadily becoming more precisely defined. The successes of both methods have been predominantly in the field of accessible cancer. Neither method has as yet proved successful in dealing with more than a small proportion of the total number of patients who develop malignant tumours at the less accessible sites. The fact that an occasional brilliant success is achieved by surgery or by radiotherapy only tends to emphasize the need for a new approach to the general problem of the treatment of deep-seated cancer. If the existing methods, so successful in early accessible cancer, are to prove effective in the wider field it is essential that means be found to promote earlier diagnosis and treatment. The Holt Radium Institute Report (Paterson, Tod and Russell, 1946) on the survival rate of 8,298 patients with cancer treated by radiation states that there was a *5-year net survival rate* of 40 per cent in all cases treated. In the early cases (one-third of the total) the 5-year *net survival rate* was 86 per cent, in the early and moderate cases together (over one-half of the total) it was 63 per cent, but in the late cases (under one-half of the total) it was only 13 per cent. At present far too many cancer patients never receive treatment at all (Mackenzie, 1939), and many of those who do reach the surgeon or the radiotherapist arrive too late to be cured.

Need for early diagnosis

Survival rates in early and late cases of cancer treated by irradiation

Surgery and radiotherapy as palliative agents

In palliative treatment radiotherapy has proved to be of such value in relieving suffering and in prolonging life that there has often been a tendency in the past for over-enthusiasm in the application of this treatment in advanced cases. Careful and detailed studies of the response of tumours at each site to irradiation are leading to a better understanding of what can be achieved, and therefore to a more accurate judgement of the likelihood of worth-while palliation being obtained. So long as great benefit occasionally resulted in what appeared to be the most unlikely cases it was difficult to justify the withholding of such treatment. The radiotherapist is still, however, not infrequently pressed by his colleagues to do something when he knows that no improvement can be expected. Such circumstances may at times lead to additional suffering due to radiation damage or even to neglect of genuinely useful palliative surgical procedures.

(2) Radiotherapy combined with surgery

Competition between surgery and radiotherapy has been steadily giving way to co-operation. Pre-operative or post-operative irradiation, or a combination of both, is employed with increasing frequency as the results of careful analyses of the effects of treatment by these methods and by surgery alone become available

(a) *Pre-operative irradiation*

Pre-operative irradiation is designed to reduce either the mitotic activity or the bulk of the tumour to an extent which will diminish the risk of dissemination of the disease at operation, and so make an inoperable condition operable. Pre-operative irradiation may be employed for many widely differing types of tumour, for nephroblastoma and for osteogenic sarcoma, for instance, but *it is of special value in certain cases of cancer of the breast* There is a tendency for more pre-operative irradiation to be employed, since it is clear that in certain circumstances the chances of success with surgery are materially improved in borderline or doubtfully operable cases.

(b) *Post-operative irradiation*

Post-operative irradiation is employed when the natural history of the disease, or the operative findings or the pathological examination suggests that the whole of the tissue involved by growth has probably not been removed. Examples of these three categories are: (i) seminoma of the testis, for which the primary growth is removed and the abdominal glands are irradiated; (ii) when the surgeon finds at operation that he has had to cut across tissue involved by growth; and (iii) in cases of carcinoma of the breast which seemed to be in an early stage clinically but which are found on histological examination to be involving numerous small glands in the axilla.

"Prophylactic" irradiation

Much has been said in the past about "prophylactic" irradiation in this connexion Post-operative treatment is designed to deal with residual malignant cells which are known or thought to be present. The practice of giving inadequate doses on the grounds that the treatment was a mere precaution was quite unsound. It was analyses of the results obtained in groups of cases so treated which, more than anything else, delayed the recognition of the value of post-operative *irradiation for some of the conditions for which it is* now employed.

(c) *Surgery of access*

Surgery and radiotherapy are sometimes combined in another way when the tumour is exposed surgically so as to give access for irradiation. This has been done in a few instances at many sites, including, for example, such unlikely places as the lung and the pancreas, but has been employed chiefly for the larynx, stomach, bladder and rectum, with varying success. The larynx (Lambert and Watson, 1942) and the bladder (Goin and Hoffman, 1941) are the only two sites in which any useful results have yet been obtained with this method.

(3) Tumours at various sites

In a brief general review such as this it is impossible to discuss the place of radiotherapy in the treatment of all types of cancer throughout the body.

Some of the more important groups will be referred to here quite briefly to give an indication of the role of radiotherapy and of what can be achieved by this method.

(a) The skin and lip

Cosmetic results with radiotherapy for tumours of the skin and lip

Both surgery and radiotherapy are successful in a high proportion of these cases. The cosmetic results with radiotherapy are so good that there is now seldom need for operations involving any extensive plastic repair. Radiotherapy is the method of choice particularly for tumours of the lip and face, in the majority of cases, with the exception of a few histological types. Surgery is generally reserved for those tumours that are known or prove to be radio-resistant and for cases requiring block dissection of involved lymph glands. With basal-cell carcinomas a high symptom-free rate should be obtained (survival rates are of no value in assessing the results of treatment in this group). For example, a 92 per cent 5-year symptom-free rate is reported by Smithers (1946). In squamous-cell carcinoma of the skin this report gives an 80 per cent 3-year symptom-free rate in stage I, and 69 per cent in all cases treated. The Holt Radium Institute Report (Paterson, Tod and Russell, 1946) gives a 65 per cent 5-year net survival rate in all cases of carcinoma of the lip treated, and Smithers (1946) gives a 67 per cent 3-year symptom-free rate.

Malignant melanomas

Malignant melanomas arise from pigmented moles. Pigmented moles are extremely common and the development of malignant change is fortunately rare. When they do become malignant their behaviour is so unpredictable that it is difficult to assess the value of any form of treatment. A "mole" may be removed years before widespread dissemination is seen, and a small pigmented tumour unsuspected of malignancy may give rise to metastases and death. They may spread slowly, producing local metastases in their vicinity, may involve the regional lymph glands only, or may give rise to blood-borne metastases in any or almost every part of the body. The histogenesis is uncertain but they may well be epidermal in origin; at least, intermediate types of pigmented basal-cell and squamous-cell carcinomas are seen. It is not surprising, therefore, that conflicting reports as to their response to radiotherapy have appeared. This response is so uncertain that surgery is to be preferred whenever there is a good prospect of removal of the tumour with a margin of normal tissue. It is probable that irradiation is sometimes of value, particularly in those cases in which spread is comparatively slow and predominantly by way of the lymphatics.

(b) Mouth and pharynx

Radium implantation, teleradium or x-ray treatment

Surgery has largely given way to radium implantation, teleradium or x-ray treatment for the primary tumours, but is still the best method of treatment available for the lymph glands when they appear to be involved clinically and are operable. A 5-year survival rate of 57 per cent in tumours of the oral cavity treated by radiotherapy in stage I, and of 25 per cent in all stages has been obtained at the Holt Radium Institute.

(c) Larynx

The surgical treatment of intrinsic laryngeal cancer is most successful in suitable cases. Laryngofissure has proved to be satisfactory in the really

early localized lesions. Good results have also been obtained with laryngectomy (Colledge, 1940–45), but this is a mutilating operation and equally good results have been obtained by irradiation either with surgery of access and radium (Finzi and Harmer, 1928), with teleradium (Lederman, 1945), or with x-rays (Baclesse, 1949), in a more representative selection of cases. Failures with radiotherapy may have a second chance with laryngectomy, but there is no effective treatment possible for a failure following radical surgery. Mount Sinai Hospital reports (Kramer, 1947) 32 cases of intrinsic laryngeal cancer treated with x-rays by Dr. William Harris with only 4 recurrences, in 1 of which the patient was subsequently cured by laryngectomy: 13 were symptom free from 5 to 11 years, 9 from 3 to 5 years, and 6 from 1 to 2 years. Lederman (1947), using teleradium, had 18 out of 23 operable patients alive at 3 years, and 12 out of 17 at 5 years. The Holt Radium Institute reports a 54 per cent 5-year net survival rate in cases of intrinsic carcinoma of the larynx without lymph-gland involvement which were treated by radium. In all cases of carcinoma of the larynx and pharynx, mostly treated by x-rays, a 5-year net survival rate of 20 per cent was obtained when glands were not involved, and of 7 per cent with lymph-gland metastases. With extrinsic laryngeal tumours x-rays and teleradium are the best methods of treatment now available.

Surgery of access and radium implantation

X-ray and teleradium treatment

(*d*) *Salivary glands*

The salivary-gland tumours vary from simple adenomas, through the most common group of adenomas and adenocarcinomas known as the "mixed tumours" (forming 90 per cent of all salivary-gland tumours) to highly malignant anaplastic carcinomas, one type showing transition to the next so that no sharp lines of distinction can be drawn. The response of these tumours to radiotherapy is correspondingly varied. Surgery may be sufficient alone for the most benign, but local removal is frequently followed by the development of another tumour in the gland, and pre-operative irradiation has proved to be of real value in preventing this in the majority of these cases. Radium implantation by itself, or more often in the wound as a post-operative procedure, is sometimes used for the more benign tumours, and x-ray or teleradium treatment by itself or as a pre-operative and post-operative measure for the more malignant tumours. Reviews of this subject have been published by Ahlbohm (1935) and Lederman (1941). The rare tumours of heterotopic salivary tubules occurring in preparotid lymph glands (Nicholson, 1922) and known as "adeno-lymphomas", "papillary cystadenomas" or "salivary adenoma of lymph glands" (Willis, 1948) are usually slow-growing, benign and easily removed. Recurrence does occur, however, and as it has been shown that even then they may respond well to irradiation (Lederman, 1943), their initial treatment by irradiation should be considered.

"Mixed" salivary-gland tumours

Radium implants

X-ray and teleradium treatment

"Adeno-lymphomas"

(*e*) *Thyroid gland*

Radiotherapy has been acquiring increasing importance in the management of thyroid tumours, chiefly as a supplement to surgery but also when used alone. The thyroid tumours cover a wide range from extreme indolence to dramatic malignancy. It is doubtful whether irradiation is of benefit for the small tumours which are found to be malignant only by careful microscopical examination of the tissues removed at operation. Pre-operative treatment is

Variable response to irradiation with x-rays

desirable for cases with evidence of invasion outside the capsule of the gland, and post-operative treatment should be given to cases found at operation to be more extensive than appeared likely clinically. As Joll (1941) pointed out, however, thyroid tumours vary so greatly in their sensitivity that it is difficult to lay down any rules, and for the present we must judge almost entirely by the result obtained in each case. An attempt to clarify this position has been made by Graham and McWhirter (1947) and a good review was written by Portmann (1941). Radio-active iodine is now being used in some cases. Tumours do not, on the whole, take up the iodine so well as does the normal thyroid tissue. Interesting work is, however, being done in advanced cases in which it has been observed that some secondary deposits will take up the iodine after the normal thyroid tissue has been eliminated by removal or irradiation.

Radio-active iodine

(*f*) *Gastro-intestinal tract*

Cancer of the oesophagus

With the possible exception of the oesophagus (where no method of treatment has yet achieved much success), radiotherapy plays a minor part in the treatment of tumours of the gastro-intestinal tract. Some palliation is obtained in many cases of carcinoma of the oesophagus either with a radium bougie or with x-rays, but few of the patients receiving treatment live for more than one year. An occasional 5-year survival is all that is obtained. Smithers (1943) reported on 51 patients seen from 1937 to 1939, 44 of whom were treated by x-rays, 32 completing treatment, with 13 of these alive after 1 year, 5 after 2 years and 3 after 5 years. Fleming (1947) reviewed the results obtained in some 800 reports of cases published by 10 writers, with only 10 patients in this series surviving for more than 5 years. Carcinoma of the cardiac end of the stomach is sometimes treated by implantation of radon seeds with marked improvement for a while. Inoperable cases of cancer of the rectum may be treated with a radium applicator or by means of high-voltage x-rays. Berven (1939) believes that all inoperable cases should have radiotherapy if the general health is fairly good, since it often provides an endurable existence for these patients for the remaining part of their lives. Phillips (1942) obtained some valuable palliation with a million-volt x-ray therapy plant. The results of palliative surgery even in the more advanced cases are, however, often as good as, if not better than, those produced by irradiation. This is one of the sites where a detailed study is required to determine which advanced cases are best treated by surgery, which by irradiation and which are best left untreated An examination of the results obtained in low rectal tumours by surgery and radiotherapy is also needed before we can decide whether radiotherapy has any place in the treatment of operable carcinoma of the rectum.

Cancer of the stomach

Cancer of the rectum

(*g*) *Genito-urinary tract*

Nephroblastoma

The embryonic tumours of the kidney—Wilms's tumour, or nephroblastoma—are said to be the most radio-sensitive tumours known. While some are extremely sensitive, there is a great deal of individual variation. This is just what would be expected from their structure, for they are mostly composed of undifferentiated embryonic renal tissue which responds readily to irradiation, but they also contain varying amounts of any of the constituents of a developing kidney in any stage of differentiation and with wide variation

in radio-sensitivity. These tumours may grow rapidly and metastasize freely so that the prognosis is grave. A few of these patients are cured by nephrectomy alone if the diagnosis is made and operation is performed while the tumour is still localized. Rapid diminution in size is usual with radiotherapy but few are cured by this means. These tumours are eminently suitable for pre-operative irradiation, for their activity and size are quickly reduced; they should then be operated upon without delay because of the tendency to metastasize, and because irradiation alone is unlikely to eliminate the more radio-resistant portions of the tumour.

Carcinoma of the renal parenchyma

Carcinomas of the kidney—hypernephroma, or Grawitz's tumour—are variable in structure and behaviour. Their tendency to invade the veins, and the unusual nature of their metastases, which are sometimes large and solitary, produce curious results in treatment and errors in diagnosis. They are not very sensitive to irradiation, and post-operative treatment is not known to be of any value. There is some evidence that pre-operative irradiation may be beneficial.

Cancer of the renal pelvis, ureter and bladder

Tumours of the renal pelvis and ureter are usually treated surgically but the bladder remains one of the sites where the relative spheres of surgery and radiotherapy are still not well defined. The difference in the results obtained by radiation in early and late cases is even more marked here than elsewhere. The multiplicity and variation in degree of malignancy of these tumours make assessment of treatment methods difficult. Early tumours can be treated by intracavitary x-ray therapy, radium needle, or radon-seed implants. *Radon-seed implants* The Holt Radium Institute obtained a 59 per cent 5-year net survival rate in early cases treated with radon, but only 7 per cent in late cases. The x-ray treatment of more advanced cases shows some promise and is worthy of a more extensive trial, but has not yet fully justified itself (Paterson, 1941). There is evidence that these tumours are moderately radio-sensitive and better results may follow the more extensive use of penetrating beams of radiation. *Radio-active isotopes* The introduction of radio-active isotopes into the bladder offers a new treatment method that may possibly be of value.

(h) *The male genital organs*

Cancer of the testis

Ewing's view that seminoma of the testis is a "one-sided development of teratoma" and that the tumours are not really separate entities is refuted by Willis (1948). The differences in age incidence, prognosis and response to irradiation all support this separation. *Seminomas* Seminomas are most responsive to irradiation. Post-operative treatment to the abdominal lymph glands is now a routine procedure. Few cases are too advanced for an attempt at treatment to be made, and this is one of the rare occasions when irradiation of the thorax for extensive secondary deposits is well worth while. The improvement in the results of treatment of seminoma in recent years has been chiefly due to radiotherapy (Gordon-Taylor, 1947). There is no evidence that, in teratomas, irradiation improves the position to a corresponding degree. *Teratomas* These tumours contain embryonic tissues of a wide range of immaturity and also adult tissues at every stage of differentiation, all of which may display differing degrees of malignancy. That response to irradiation should be variable, and that though the progress of the disease may be delayed it should seldom be arrested, is therefore not surprising

Cancer of the prostate

Cancer of the prostate occurs on an average in people older than those in whom any other malignant tumour develops; it frequently escapes diagnosis clinically, may progress very slowly and is commonly found first at autopsy. The assessment both of incidence and of the results of treatment is, therefore, difficult since the expectation of life in the group of patients concerned is low without prostatic cancer, but some individuals may, nevertheless, live for a number of years with active disease present. The only known method of cure is removal of the tumour in the early stage of the disease. The growth of these tumours is inhibited by oestrogens and some symptomatic improvement is thereby obtained in the majority, so that radiotherapy has been employed less and less of recent years. It is sometimes still of value in the relief of pain when oestrogens have failed.

(i) *The female genital organs*

Cancer of the cervix uteri

The great majority of cases of carcinoma of the cervix are now treated by means of radium, often with supplementary x-ray therapy to the parametria and glands (Lederman and Lamerton, 1948; Winternitz, 1948). An absolute 5-year survival rate of 80 per cent was obtained by Hurdon (1942) with radium treatment in cases in stage I, and of 35 per cent in all cases seen.

Cancer of the corpus uteri

Carcinoma of the body of the uterus is still generally regarded as a surgical problem, but recent work by Heyman (1947), following his pioneer work in the treatment of cancer of the cervix, suggests that radium treatment must now be seriously considered as an alternative method for the treatment of tumours at this site. Heyman's figures show a 5-year cure rate of 54·2 per cent in 670 cases treated from 1914 to 1939 (67 per cent in 304 cases clinically operable, 48 per cent in 279 cases technically operable but unsuitable for surgery on other grounds or refusing operation, and 28·7 per cent in inoperable cases). The relative cure rates for the cases treated in the years 1914–33 and 1934–39 were 45 per cent and 64·9 per cent respectively, the improvement having followed the introduction of his new method of packing the uterus with radium sources (Fig. 148 (b)).

Cancer of the ovary

Secondary deposits in the ovary are commoner than primary malignant tumours, errors in diagnosis are frequent and practically all analyses of the results obtained by various treatment methods are valueless. A number of primary ovarian tumours do well with surgery alone and indiscriminate post-operative irradiation should be avoided. Ackerman and del Regato (1947) state that: "If a serous cystadenocarcinoma or a pseudomucinous cystadenocarcinoma is not completely removed or is found beyond the ovary at the time of surgery, then post-operative irradiation is mandatory, for there seems to be little doubt that such irradiation prolongs life, gives definite [illegible] deciding factor in cure." Not everyone [illegible] noma or seminoma-like tumour is [illegible] rative treatment may be of value, though these tumours have not the same marked tendency to dissemination as seminomas.

(j) *The breast*

A study of the factors influencing prognosis in carcinoma of the breast shows that the stage or degree of advancement of the disease at the time that treatment is started is by far the most important. Excellent results are

obtained with radical mastectomy alone in early cases; 5-year survival rates of 70–80 per cent in clinical stage I being obtained, and rates of over 80 per cent if clinical staging is abandoned and only those without microscopical evidence of axillary lymph-gland involvement are included (Gordon-Taylor, 1938). Such figures do not, however, give a clear picture of what is done for all patients with cancer of the breast. Absolute 5-year survival rates of over 30 per cent for all patients seen, whether treated or not, are seldom obtained except in the larger treatment centres where adequate radiotherapy is available. This is due to the poor results obtained, other than with the earliest cases, in those centres where radical mastectomy is regarded as the primary method of treatment to be adopted whenever possible. In all but the earliest cases better results can be achieved with pre-operative irradiation (Richards, 1948, and Ledlie, 1948), or with local mastectomy and irradiation of the axillary and supraclavicular lymph-gland areas (McWhirter, 1946 and 1948), owing to the risks of dissemination of the disease inherent in an unsuccessful dissection of the axilla. Radiotherapy alone is a valuable means of palliation in late cases and for some metastases; it sometimes eliminates the primary growth completely. Preliminary irradiation reduces the risks of dissemination by operation, but operation is usually necessary to remove the residual tumour so frequently left after irradiation. It would seem unwise to limit operation to local mastectomy when successful post-radiation clearance of the axilla seems practicable.

Radical mastectomy alone for early cases

Pre-operative radiotherapy for later cases

Radiotherapy alone for late cases

Radiotherapy employed as an integral co-ordinated part of the treatment with surgery greatly improves the patient's chance of survival. Its chief uses are pre-operatively in all but the earliest cases, post-operatively in cases which are thought to be early clinically but are found microscopically to have more extensive spread than was expected yet still have some prospect of cure, and alone as a palliative agent in the remainder.

(*k*) *The bronchi*

Pneumonectomy is the most effective available method of treatment, but is unfortunately applicable only to a small proportion of the cases seen in hospital, and to an even smaller proportion of the whole. X-ray therapy provides valuable palliation, particularly in the relief of cough, dyspnoea and haemoptysis, though not so certainly in the relief of pain, and has a few 5-year survivals to its credit (Craver, 1940; Dobbie, 1944; Hilton, 1945a). Neither method shows any signs at present of being an answer to the problem presented by the majority of the patients seen, though there has as yet been little attempt made to give radical x-ray therapy to a large number.

Cancer of the bronchus

(*l*) *Tumours of bone*

Osteogenic sarcomas have proved to be a disappointing group of tumours from the treatment standpoint, having a poor survival rate after amputation owing to their marked tendency to metastasize to the lungs, and showing little response to irradiation in the majority of cases. Pre-operative radiotherapy seems to improve the surgical results (Cade, 1947), but further work is required before this point can be decided.

Osteogenic sarcomas

The giant-cell tumour of bone, or osteoclastoma, is not invariably benign and may invade surrounding tissues or metastasize. These tumours have been treated by irradiation with good results in a number of cases (Pfahler and

Osteoclastoma

Parry, 1932; Hilton, 1945b). The response is slow, and initially there may be an increased osteolytic reaction, but the tumour usually undergoes a steady decrease in size with progressive recalcification.

Reticulum-cell sarcomas

Reticulum-cell sarcomas of bone are rare; they form large tumours with massive bone destruction and show a variable but sometimes satisfactory response to radiotherapy.

Ewing's tumour

The radio-sensitive tumours which usually occur in long bones in younger people and give rise to bone destruction, diffuse elevation of the periosteum, sometimes "onion skin" subperiosteal new bone formation, and a warm soft tissue swelling are generally grouped together under the title of Ewing's tumour. Willis (1940) maintains that Ewing's tumour is not a pathological entity, that most of the tumours in this group are metastatic and many are secondary neuroblastomas. This explanation would account for the fact that despite the radio-sensitivity and local radio-curability of the tumours, most of the patients still die of their disease. In a few of the successful cases the tumours have possibly been reticulum-cell sarcomas.

Multiple myelomatosis

Plasma-cell myelomatosis produces multiple soft tumours of the bone marrow with well-defined rounded areas of bone destruction. Although the individual lesions are sensitive to irradiation, which may sometimes be of value for relief of pain, the disease is a generalized one which has not so far responded to any method of treatment.

Solitary plasmocytomas

The rare solitary plasmocytomas (the majority are only isolated lesions preceding generalized multiple myelomatosis) when they do occur respond well to irradiation and have a good prognosis.

(m) *Intracranial tumours*

Gliomas

The gliomas vary greatly in degree of differentiation and have acquired a correspondingly complex classification and terminology. Mixed forms are common, but those composed predominantly of one well-differentiated cell type are named after the cells they resemble—astrocytoma, oligodendroglioma and ependymoma—and show little response to irradiation. The undifferentiated gliomas are more radio-sensitive but may be multiple or diffuse and, though they do not metastasize by the blood stream, are liable to thecal dissemination. Radiotherapy is not often of more than temporary benefit, but some good results have been obtained (Peirce and his colleagues, 1945; McWhirter, 1946).

Embryonic tumours

The medulloblastomas and neuro-epitheliomas do respond to irradiation. So sensitive are the medulloblastomas that some successes have been obtained in advanced and apparently hopeless cases. On admission of the [illegible]

[illegible]

loblastoma is confirmed, radiotherapy is commenced [illegible]. The practice is to irradiate the cerebellum and the whole length of the spinal cord, owing to the frequency of dissemination in the spinal meninges. The rare [illegible] are also said to be radio-

[illegible]

Pituitary chromophobe adenomas

Chromophobe adenomas of the pituitary gland [illegible] the results are improved by the addition of post-operative irradiation.

Henderson (1939) published a follow-up study of the results obtained in Harvey Cushing's series With trans-sphenoidal operation only 22 out of 67 were without recurrence at 5 years (32 8 per cent), with transfrontal operation only 23 out of 40 (57·5 per cent), with trans-sphenoidal operation and post-operative x-rays 32 out of 49 (65·3 per cent) and with transfrontal operation and x-rays 27 out of 31 (87·1 per cent). A few patients with recurrence following surgery who had not been irradiated post-operatively did well with irradiation, one being alive 16½ years later.

Eosinophil adenomas acromegaly

In acromegaly the rate of progress may be slowed down and in some cases the symptoms relieved and the disease checked by radiation alone Symptoms due to hypersecretion rather than to tumour size are best treated by irradiation from the first, but chiasmal compression requires operation before irradiation.

Basophil adenomas Cushing's syndrome

Basophil adenomas are rare and do not grow to any considerable size as do chromophobe and eosinophil adenomas. They produce symptoms due to endocrine disturbance rather than compression. Their response to irradiation is variable but sometimes excellent. Since Cushing's syndrome is itself variable, and since the adrenals contribute to the glandular disturbance, a constant response to pituitary irradiation is hardly to be expected. Some cranio-pharyngeal carcinomas have been reported as responding satisfactorily to irradiation.

Meningiomas

Meningiomas are comparatively common intracranial tumours. The majority are well defined, nodular and slow-growing, and therefore much more suitable for surgery than for irradiation. Variation occurs, however, in behaviour, structure and form, and since some show infiltration, more rapid growth, and the formation of plaques of tumour with diffuse spread, McWhirter's (1946) contention that some are radio-sensitive may be of importance.

Vascular tumours

Some good results have been obtained with radiotherapy in so-called "haemangioblastomas". It is probable that the majority of these were malformations or vascular abnormalities rather than true vascular tumours; probably the commonest is the capillary angioma of the cerebellum usually found in young adults.

(n) *Sarcomas of soft tissue*

The fibrous, fatty, mucoid, synovial or muscular sarcomas vary widely both in their tendency to metastasize and in their rate of growth. Surgery has therefore had some success, but, taking this group of tumours as a whole, the ultimate outlook for these patients is far from satisfactory. Radiotherapy has in the past had little to offer, but some of these tumours have perhaps been dismissed too lightly as hopelessly radio-resistant. Further experimental work on fractionation of the dose is required before we can decide that irradiation has no part to play in their treatment. Pre-operative radiotherapy may be of value in some cases and is worthy of a more extensive trial in groups which have a poor prognosis with surgery alone.

(o) *Tumours of lymphoid and haemopoietic tissues*

Few of the conditions included under this heading are ever cured by any means at present at our disposal. Radiotherapy is the outstanding method of palliative treatment, being invaluable for the relief of symptoms, sometimes

prolonging life, and occasionally giving such a long period of symptom-free existence as to warrant the assumption of cure.

The long gradation of lymphatic tumours merging into one another, from the benign lymphoma through giant follicular lymphadenopathy (lymphoid follicular reticulosis (Robb-Smith, 1938)), and lymphosarcoma, to lymphatic leukaemia, all respond to irradiation in varying degrees. The not uncommon condition (giant follicular lymphadenopathy) showing enlargement of lymph glands with highly differentiated lymphoid tissue packed in follicles, usually enlargement of the spleen and a marked tendency to serous effusions, should always be treated by irradiation. Despite the liability of this condition to terminate in lymphosarcoma, these patients may live for many years but are apt to die from pleural effusion and heart failure if irradiation treatment is not given. This is one of the few conditions in which irradiation of the thorax will usually cause complete absorption of a pleural effusion. In a few cases, lymphosarcomas are apparently successfully treated by irradiation but their tendency to widespread dissemination, and their multifocal origin usually succeeds in overcoming their radio-sensitivity. The member of this group of tumours known as Hodgkin's disease, lymphadenoma or fibro-myeloid medullary reticulosis occurs on the average a little earlier than lymphosarcoma. Radiotherapy is most valuable in palliation, to reduce the size of lymph-gland masses, to relieve pressure (particularly on the superior vena cava or the spinal cord), to relieve pain (particularly in the common deposits in bone) and so to improve the patient's general condition and prolong life. The observation (Slaughter and Craver, 1942; Robb-Smith, 1947) that the prognosis is better in those patients in whom the disease is at first limited to one accessible group of glands which are removed surgically, is of particular interest, adding weight to the belief that metastatic spread plays a part in the dissemination of this disease the widespread nature of which is not perhaps solely due to its multifocal origin. An account of the use of radiotherapy in Hodgkin's disease has been given by Gilbert (1939). There are a number of other variants of this group of tumours with differing responses to irradiation. The leukaemias, which differ from other members of this group of tumours chiefly by the presence of malignant cells in large numbers in the circulating blood, are too widely disseminated for cure by present methods of irradiation. Whether the use of chemotherapy, for example urethane (Paterson and her colleagues, 1946), or chloroethylamine (nitrogen mustard) (Goodman and his colleagues, 1946, Jacobson and his colleagues, 1946), and radioactive isotopes such as P^{32} (Erf, Tuttle and Lawrence, 1941; Craver, 1942; Warren, 1940 and 1945) may hold out some hope either alone or in combination for the treatment of the leukaemias or for other lymphoid or haemopoietic tissue tumours has not yet been determined.

Giant follicular lymphadenopathy

Lymphosarcomas

Hodgkin's disease

Leukaemias

Chemotherapy

Radio-active isotopes

7. RADIOTHERAPY FOR NON-MALIGNANT CONDITIONS

(1) Field of application

Wide field of application in non-malignant disease

This important subject can only be touched on in the briefest manner here. The value of irradiation in many widely differing non-malignant conditions, from spondylitis to sycosis and from sterility to syringomyelia, has been offset by the tragedy of the cases in which serious damage has been done. The very real benefits that can be obtained are not yet being exploited, partly because

of ignorance on the part of physicians and surgeons of the effects that can be produced, and partly because of a lack on the part of the radiotherapist of a clear idea of indications and contra-indications, and the use either of too large doses or of small doses too often repeated. This has led to the neglect of ■ method of treatment which, for some conditions, is superior to those more commonly employed, and also to its use—at a risk of damage to the patient—in other cases for which safer and more appropriate methods of treatment are available. It is to be regretted that an amount of detailed work equal to that carried out on the effects produced by irradiation in the treatment of cancer has not been done for non-malignant disease. This subject is certainly worthy of much more attention than it has received in the past.

Radiation is a powerful and destructive agent capable of doing serious damage to normal tissues and should be employed only by those who have a sound knowledge of the effects produced and the means of controlling accurately the dose delivered. Non-malignant conditions that fail to respond to small doses seldom do better when the dose is raised, and even small doses, well below the skin erythema level, may lead to disaster if applied to the same area on a number of occasions over a long period of time. Finzi (1947) has been one of the leading advocates of reducing the dose given for non-malignant disease and has done much both to improve the results and to reduce the risks thereby. Radiotherapy should not be employed in the treatment of diseases that can be easily dealt with by other methods, or in chronic intractable diseases for which it produces only temporary alleviation of symptoms. Pruritus ani and pruritus vulvae may be cited as examples of the conditions for which radiotherapy is usually contra-indicated, although temporary improvement may result. The patient later demands repeated treatment, and, if this is refused, may go to another department in the hope of obtaining further relief by irradiation. In this way treatment may be repeated with diminishing effect until serious damage is done. Radiotherapy in non-malignant diseases finds its chief application in the treatment of certain infective conditions, in its influence on glandular secretion, in the alteration produced in some vascular malformations and certain abnormalities of reparative growth, and in the effect that follows the treatment of some simple tumours.

Small-dose treatment

Contra-indications to radiotherapy

(2) Main uses

(a) *Infections*

X-rays are of value in the treatment of many infective conditions. Some acute infections may respond rapidly to doses of the order of 25–50 r, repeated once or twice daily for 2 or 3 days. They may be used with success in the treatment of many chronic infections that have failed to respond to the more usual forms of treatment, again in doses of about 25–50 r but spread out perhaps to once a week for 4–5 weeks. The response is probably not due to any direct bactericidal effect, nor to alterations in blood supply, nor to the breakdown of defence cells in the irradiated volume and the liberation of antibodies—all theories that have been advanced to explain the action. None of these theories alone explains adequately the clinical response or accords with the experimental results obtained. The most probable explanation so far advanced of the beneficial effect of irradiation in inflammation

Use of irradiation in infections

Differentiating effect on mesenchymal cells seems to be that it encourages differentiation in mesenchymal cells (Freund, 1947). This would account for the improvement noted in results following the use of smaller doses, the effect on non-infective inflammatory processes, *Wound healing* and the increase in the speed of wound healing. Amongst the many inflam- *Actinomycosis* matory conditions treated, a few such as actinomycosis, for which irradiation properly administered is of such value that it is usually the method of choice, osteomyelitis of the fingers (Baker, 1947), post-operative parotitis (Latchmore, La Touche and Shucksmith, 1940) and rosacea keratitis may be quoted as examples.

Tuberculosis There is the whole question of the use of radiotherapy in tuberculosis which requires clarification. There is, however, no doubt of its value in tuberculous adenitis and in some cases of tuberculosis of the urogenital tract. Its limited but valuable contribution to the treatment of sarcoidosis with enlarged mediastinal lymph glands is worthy of note in view of the conflicting statements that have been made.

The value of radiotherapy in some infections is due to its ability to produce *Epilation* epilation and so secure drainage of the hair follicles. It is used for epilation in ringworm of the scalp in children and in some cases of sycosis barbae in adults.

(b) *Alteration of glandular secretion*

Reduction of glandular secretion Some of the beneficial effects of radiotherapy in dermatology are also due to the reduction of activity in sebaceous or sweat glands. There are many other uses for irradiation in medicine on account of this ability to alter glandular secretion. It is sometimes useful, for instance, in reducing the activity of salivary glands when there is chronic infection with blocking of ducts or sinus formation. Radiotherapy is often employed in the treatment of *"Chronic mastitis"* "chronic mastitis" to reduce the hyperplastic reaction and relieve pain. Although it is not denied that symptomatic improvement often results, the wisdom of this procedure is uncertain. The treatment is unnecessary and ineffectual for the lobular, non-cystic hyperplasia of adolescents and young adults which may regress spontaneously or go on to the formation of fibroadenomas—"adenosis" (Dawson, 1933) Its late effects are uncertain in the cystic hyperplasia that occurs in adult life and which, to the histologist, at least, is so commonly associated with the development of carcinoma—"epitheliosis" (Dawson, 1933). Radiotherapy to the breasts does not alter the underlying endocrine disturbance. Repeated treatments add another irritant and may even increase the risk of advance to malignancy. A single course of treatment, however, with low doses for relief of symptoms, in a patient who will be kept under observation is often useful and probably harmless.

Radiotherapy is also used to affect the secretion of endocrine glands. In *Thyrotoxicosis* thyrotoxicosis it has been of value particularly in some cases in young people, or when operation has been undesirable for other reasons, and when recurrence of symptoms has followed thyroidectomy (Poulton and Watt, 1937; Pfahler, 1940). The work now being done with radio-active iodine has revived interest in the subject and suggests that radiotherapy may have a more important part to play in the treatment of this disease in the future (Chapman and Evans, 1946; Hertz and Roberts, 1946; Marinelli and his

colleagues, 1947). Irradiation of the ovaries, and sometimes of the pituitary gland as well, has been used in the treatment of certain cases of sterility; *Sterility* although some success has undoubtedly been achieved, further work is required to place this treatment on a secure scientific footing. Intra-uterine radium or preferably external application of x-rays to the ovaries (except in fat women) has for long been a recognized method of producing an artificial *Artificial menopause* menopause. This is a simple, safe and reliable procedure especially in women of over 40 years of age and is extensively used in the treatment of menopausal menorrhagia and of endometriosis and by some as an addition to *Endometriosis* other treatments for certain cases of carcinoma of the breast.

(*c*) *Simple tumours and malformations*

Radiotherapy is often effective as a treatment for virus warts though a *Virus warts* number are resistant and many require doses of the order of 1,000 r or even as much as 2,000 r to cause regression. Such large single doses to areas of more than a few millimetres in diameter are dangerous. Radiation necrosis is particularly serious on the hands and feet where warts are common and disastrous disability may result, for it is notably difficult to deal with necrosis adequately by plastic repair in these situations. "Pitch warts", the pre- *"Pitch warts"* malignant tumours that occur in those exposed at work to pitch and tar, can usually be removed by irradiation (Hieger and his colleagues, 1947). They appear chiefly on the face, scrotum and forearms and are very rarely seen on the feet; particular care is required and alternative methods of treatment should be considered when these lesions are encountered on the hands. The transition from "pitch wart" to squamous-cell carcinoma is a gradual process; it may be very slow but there is no clear-cut dividing line between the two.

Angiomas, vascular malformations or "birth marks" are often removed *Angiomas* by irradiation. They vary considerably in structure but though one type may predominate they are frequently mixed. The "mulberry naevi" or "strawberry marks" usually give the best results, the "spider naevi" less good, and the "port-wine stains" the worst. They are treated with *beta*-ray plaques, radium applicators, low-voltage x-rays or sometimes by the application of thorium X. X-rays are useful for the treatment of keloid scars, being of *Keloid* special value when combined with plastic surgery and used both pre-operatively and post-operatively when keloid is known to be likely to develop (Levitt and Gillies, 1942).

8. RADIATION DAMAGE

Radiation is a destructive agent and serious damage to normal tissues may result from its careless use (McIndoe, Forbes and Windeyer, 1947). This fact has done much to restrict the use of a valuable treatment method of wide application in medicine and surgery, and even to bring it into disrepute. Radiotherapy is a young branch of medicine, being only just 50 years old. Its dangers were not fully appreciated in the early days and a number of *Dangers to workers in radiation* workers died or were seriously injured as the result of exposure before adequate methods of protection were instituted. Such cases are now rare but do still occur at times in those who use radiation without any proper training or knowledge of its effects. The author has seen quite recently one most

distressing case of extensive damage to the hands of an orthopaedic surgeon who had been using an x-ray plant with a fluorescent screen for checking the position of bones after the reduction of fractures and for guiding the insertion of Smith-Petersen pins.

Necrosis of skin

The majority of cases of radiation damage to the skin occurs in the treatment of non-malignant conditions. They may occur from overdosage, as acute necrosis of skin immediately following the treatment, or as late necrosis following progressive fibrosis, telangiectasis and hyperkeratosis which can occur months or even many years afterwards Necrosis can also result from moderate doses delivered to particularly sensitive areas, such as the perineum, particularly when large fields are used, or from small doses repeated a number of times to the same area over a period of months or years. With increasing knowledge of the effects of radiation on tissues, the use of smaller doses in non-malignant conditions and an awareness of the dangers involved, these disasters should be reduced in number, though some cases treated many years ago which develop late necrosis will still be seen. Large single doses should never be applied to the hands and feet. Radiotherapy is contraindicated in the treatment of hyperhidrosis, hypertrichosis and in most cases of pruritus ani and pruritus vulvae. Repeated courses of treatment, even with small doses, to the same skin area are dangerous. This practice has been common in the past and in a number of cases (of syringomyelia for instance) necrosis or squamous-cell carcinoma of the skin has developed as a result.

Sensitive skin areas

Dangers of repeated small doses

Contra-indications to irradiation in non-malignant conditions

Small margin of safety in the treatment of malignant disease

In the treatment of malignant disease the position is rather different. The margin between an effective dose and a necrotic dose is sometimes small, and the radiotherapist who, by playing for safety, never produces a necrosis may well not be serving the best interests of the majority of the patients with cancer whom he attempts to cure. An occasional late necrosis years after the successful treatment of inoperable cancer, however distressing, is the price that has sometimes to be paid for survival. All cases of radiation necrosis that do occur should be reported to the department where the treatment was given so that they may be investigated and so that the true incidence of necrosis produced in any one department shall be known by those who work in it. Surgery should be employed whenever possible for tumours at those sites where radiation necrosis is particularly liable to occur. There are a few possible exceptions to this when it is clear that surgical removal of the whole necrotic ulcer would be a practicable procedure if the treated area were to break down. A simple example is squamous-cell carcinoma of the pinna, many cases of which do well with radiation and heal satisfactorily although in a few instances necrosis is bound to occur owing to the lack of a good subcutaneous tissue base and the proximity of cartilage. Necrosis can be simply dealt with by surgery when it does occur, and the majority of patients are spared the disfigurement consequent upon removal of the pinna.

Necrosis of bone

Necrosis of bone occurs at times following irradiation, particularly in the mandible after treatment of tumours of the buccal cavity by means of teleradium, when infection and trauma have been added. The final breakdown is usually precipitated by the removal of teeth which were allowed to remain at the time the treatment was given.

Necrosis of the ribs and clavicles is seen occasionally in patients who have been treated for carcinoma of the breast by x-rays or radium implants. There

has been a number of reports of cases of fracture of the neck of the femur in recent years in patients who have received irradiation treatment for tumours of the pelvis. These necroses and fractures of bone occur some months or years after treatment and are almost certainly due to interference with the blood supply as a result of endarteritis. They are brought to light by trauma, infection, or revascularization from the surroundings fibrous tissue leading to absorption of the dead bone

Necrosis of nerve tissue

Necrosis of other tissues such as the brain or spinal cord may also follow irradiation, probably as the result of diminution in the blood supply. Irradiation with large doses to large volumes of tissue may lead to extensive deep fibrosis with limitation of movement, and involvement of nerves producing intractable pain.

Deep fibrosis

Stress has been laid deliberately upon radiation damage despite the fact that in malignant disease the number of cases in which serious necrosis takes place is small. Advances providing a sounder biological basis for dosage should do much to eliminate these, but some risk is justifiable in the treatment of cancer when the alternative of underdosage carries an even greater risk.

REFERENCES

Ackerman, L. V., and Regato, J. A del (1947) *Cancer. Diagnosis, Treatment and Prognosis.* St. Louis; Mosby. London; Kimpton.
Ahlbohm, H E. (1935) *Acta Radiol Stockh.*, Suppl 21.
Baclesse, F. (1949) Address to British Institute of Radiology, March, 1947. (In the press.)
Baker, Alfreda H. (1947) *Proc. R Soc. Med*, 40, 111.
Berven, E. G. E (1939) *Acta Radiol Stockh.*, 20, 373.
British Institute of Radiology (1947) "Report of London Conference, 1946" *Brit J. Radiol*, 20, Suppl 1
Cade, S. (1947) *Brit J Radiol.*, 20, 10.
Chapman, E. M, and Evans, R. D. (1946) *J. Amer. med Ass*, 131, 86
Colledge, L. (1940–45) *Trans. med Soc Lond*, 63, 306
Craver, L. F. (1940) *Amer. J. Roentgenol.*, 43, 469.
— (1942) *Bull N.Y Acad Med*, 18, 259.
Dale, W. M. (1942). *Biochem J*, 36, 80
— (1943) *Brit. J Radiol*, 16, 171.
Dawson, Edith K (1933) *Edinb med J*, 40, 57
Dobbie, J. L. (1944). *Brit J. Radiol*, 17, 107
Erf, L. A., Tuttle, L. W., and Lawrence, J. H. (1941). *Ann intern Med*, 15, 487
Finzi, N. S (1947) *Proc R Soc. Med.*, 40, 115.
— and Harmer, W D. (1928) *Brit. med. J*, 2, 886
Fleming, J. A. C (1947) *Thorax*, 2, 206.
Freund, F (1947). *Proc. R. Soc. Med*, 40, 113
Gilbert, R (1939). *Amer. J. Roentgenol*, 41, 198.
Glücksmann, A (1941) *Brit J Radiol.*, 14, 187.
— and Spear, F G (1945) *Brit. J Radiol*, 18, 313.
Goin, L S, and Hoffman, E. F (1941). *Radiology*, 37, 545.
Goodman, L. S, Wintrobe, M. M, Dameshek, W., Goodman, M J, Gilman, A, and McLennan, M. T. (1946) *J. Amer. med Ass*, 132, 126
Gordon-Taylor, G (1938). *Brit. med J.*, 2, 1071
— (1947) *Brit J Surg*, 35, 6
Graham, J. M., and McWhirter, R. (1947) *Proc. R Soc Med*, 40, 669
Gray, L H. (1944) *Brit J. Radiol*, 17, 327.
Henderson, W R. (1939) *Brit J Surg*, 26, 811

Hertz, S., and Roberts, A. (1946). *J. Amer. med. Ass.*, **131**, 81.
Heyman, J. (1947). *Brit. J. Radiol.*, **20**, 85.
Hieger, I., Henry, S. A., Ross, P., and Winternitz, J. G. (1947). *Brit. J. Radiol.*, **20**, 145.
Hilton, Gwendoline (1945a). *Brit. J. Tuberc.*, **39**, 51.
— (1945b). *Lancet*, **1**, 110.
Honeyburne, Joan, Lamerton, L. F., Smithers, D. W., and Mayneord, W. V. (1939) *Brit. J. Radiol.*, **12**, 269.
Hurdon, Elizabeth (1942). *Cancer of the Uterus*. London; Oxford University Press
Jacobson, L. O., Spurr, C. L., Barron, E. S. G., Smith, T., Lushbaugh, C., and Dick, G. F. (1946). *J. Amer. med. Ass.*, **132**, 263.
Joll, C. A. (1941). *Post-Grad. med. J.*, **17**, 166.
Koller, P. C. (1946). *Brit. J. Radiol.*, **19**, 393.
— and Smithers, D. W. (1946) *Brit. J. Radiol.*, **19**, 89.
Kramer, R. (1947) *J. Mt Sinai Hosp.*, **14**, 24.
Lambert, V., and Watson, T. A. (1942) *J. Laryng.*, **57**, 222.
Latchmore, A. J. C., La Touche, A. A. D., and Shucksmith, H. S. (1940) *Lancet*, **1**, 497.
Lea, D. E. (1946) *Actions of Radiations on Living Cells* Cambridge; Cambridge University Press.
Lederman, M. (1941) *Brit. J. Radiol.*, **14**, 329.
— (1943). *Ibid.*, **16**, 383.
— (1945). *Proc. R. Soc. Med.*, **38**, 356.
— (1947). *Societé Français d'Oto-Rhino-Laryngologie Congrès de 1947*, C. R. Vol 54, pt II, p. 63
— and Lamerton, L. F. (1948) *Brit. J. Radiol.*, **21**, 11.
Ledlie, R. C. B. (1948) *Brit. J. Radiol.*, **21**, 610
Levitt, W. M., and Gillies, H. (1942) *Lancet*, **1**, 440
Mackenzie, [redacted] (1939) *Rep. publ. Hlth med. Subj., Lond.*, No. 89. London; H.M. Stationery Office.
Marinelli, L. D., Foote, F. W., Hill, R. F., and Hocker, A. F. (1947). *Amer. J. Roentgenol.*, **58**, 17.
Mayneord, W. V. (1932). *Brit. J. Radiol.*, **5**, 677
McIndoe, A. H., Forbes, R., and Windeyer, B. W. (1947) *Brit. J. Radiol.*, **20**, 269
McWhirter, R. (1946) *Proc. R. Soc. Med.*, **39**, 673
— (1948). *Brit. J. Radiol.*, **21**, 599.
— Hilton, G., and Phillips, R. (1938) Report of Society of Radiotherapists, May, 1938 (Circulated privately.)
Meredith, W. J. (1947). *Radium Dosage. The Manchester System.* Edinburgh; Livingstone.
Nicholson, G. W. (1922). *Guy's Hosp. Rep.*, **72**, 333
Paterson, Edith, Haddow, A., Thomas, Inez A., and Watkinson, Jean M. (1946) *Lancet*, **1**, 677.
Paterson, R. (1941) *Brit. J. Radiol.*, **14**, 219.
— and Parker, H. M. (1934) *Brit. J. Radiol.*, **7**, 592.
— Tod, Margaret, and Russell, M. (1946) *The Results of Radium and X-ray Therapy in Malignant Disease*. Edinburgh, Livingstone.
Peirce, C. B., Cone, W. V., Elvidge, A. E., and Tye, J. G. (1945) *Radiology*, **45**, 247
Pfahler, G. E. (1940). *Radiology*, **34**, 43
— and Parry, L. D. (1932). *Amer. J. Roentgenol.*, **28**, 151.
Phillips, R. (1942) *Proc. R. Soc. Med.*, **35**, 768.
Portmann, U. V. (1941). *Amer. J. Roentgenol.*, **46**, 454.
Poulton, E. P., and Watt, W. L. (1937) *Proc. R. Soc. Med.*, **31**, 371
Richards, G. E. (1948) *Brit. J. Radiol.*, **21**, 109
Robb-Smith, A. H. T. (1938). *J. Path. Bact.*, **47**, 457
— (1947). *Recent Advances in Clinical Pathology*. London; Churchill

Slaughter, D. P., and Craver, L. F. (1942) *Amer. J. Roentgenol.*, **47**, 596.
Smithers, D. W. (1943). *Brit. J. Radiol.*, **16**, 317.
— (1946) *The X-ray Treatment of Accessible Cancer.* London; Arnold.
Spear, F. G. (1946). *Brit. med. Bull.*, **4**, 2.
Strandqvist, M. (1944). *Acta Radiol. Stockh*, Suppl. 55.
Warren, S (1940). *New Engl. J. Med.*, **223**, 751.
— (1945). *Amer. J. med. Sci.*, **209**, 701.
Willis, R. A (1940). *Amer. J. Path*, **16**, 317.
— (1948). *Pathology of Tumours.* London; Butterworth.
Wintemitz, J. G. (1948). *Brit. J. Radiol*, **21**, 27.

[References to other titles are given under Radiotherapy in the Index Volume.]

RECONSTRUCTION OF THE EAR AND NOSE

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PART I

RECONSTRUCTION OF THE EXTERNAL EAR

1. INTRODUCTION

287.] The exact reproduction of the complex architecture of the ear in its entirety presents a goal which is not often reached, but in congenital cases there is good prospect of a normal-looking ear following surgery. Many partial losses, too, can be very accurately restored and are a profitable field for surgical relief. Furthermore, patients in the younger age-groups who have congenital and traumatic losses of the auricle almost always prefer to have a reconstruction of living tissues, incomplete match though it may be to the intact opposite side, rather than a prosthesis which can be an almost perfect reproduction of the living ear in form, colour and texture, but volatile and vulnerable.

2. PARTIAL RECONSTRUCTIONS OF THE EAR

(1) Repair of meatal stenosis

(a) By "Z" plastics

Membranous strictures may be corrected by a series of "Z" plastics. A circular incision is made round the free edge of the stricture. A series of "Z" flaps, with apices of about 60 degrees, are then cut and the points of these flaps interdigitated in the usual way for "Z" plastics, and fixed in position with fine silk sutures.

This method is applicable only when the stricture is a narrow one. *For narrow strictures*

(b) By free skin graft

Some more extensive strictures may be successfully treated by excision and repair of the lining defect in the canal by a free split-skin graft borne on a stent mould. *More extensive strictures*

(c) By inverted tube pedicle

For other strictures a radical excision of the scar throughout the whole extent of the affected part of the meatus is necessary. The cylindrical defect so established is lined with an inverted tube pedicle fashioned from post-auricular skin. This tube pedicle is based superiorly and is inserted into the canal through a post-auricular incision. Exposed raw surfaces of the base of the tube pedicle, after attachment of the free end deeply to the intact portion of the canal, may be covered by a thin split-skin graft. After 2–3 weeks the upper attachment is divided, the new meatus is fashioned from the tube pedicle, and the post-auricular incision is closed. *Other strictures*

(2) Reconstruction of lobe

Very reasonable reconstructions of the lobe may be obtained by the use of quadrilateral flaps based proximally on mastoid or cheek areas, cut about twice as long as broad and then folded on themselves to give cover and lining to the new lobe. The base is divided 2 weeks later and local excisions and scar revisions are carried out as necessary. *Quadrilateral flaps*

(3) Reconstruction for loss of ear margins

Small marginal losses, that is, up to about 2 centimetres in vertical extent, are often best restored by direct approximation, which may involve excision of a wedge of more central concha and skin. If this produces obvious asymmetry with the normal ear, then either the normal ear may be reduced, or longer-term methods of repair of the affected side may be adopted. *Overcoming asymmetry*

When a narrow portion of the margin of more than 2 centimetres is missing, as is very frequently the case in the burnt ear, a suitable repair can be obtained by training a post-auricular, non-hairy, mastoid flap so that it can eventually be placed on the margin of the ear and its place on the mastoid taken by a free skin graft (Fig. 159). An alternative method is the replacement of the rim by a long narrow tube pedicle from the neck, raised and transported into position in stages. *Repair of burnt ear*

Partial losses of the ear involving more than the rim may need the insertion of extra cartilage in addition to soft tissue cover if the repair is to be a good one. Such cartilage may come from the opposite side, thereby reducing the total amount needed to produce a symmetrical ear; or cadaver or preserved ox cartilage may be used. *Cartilage insertion*

(4) Construction of skin tunnels to aid attachment of prosthesis

Vultex prosthesis

A perfectly satisfactory fixation of most vultex and other prostheses may be obtained by skin glues, some of which can give a secure attachment for 24–72 hours, and may often be used for a period of months and years without causing skin irritation. Nevertheless, to most patients, such glues are a less satisfactory method of fixation than can be obtained by the construction of small tube pedicles under which extensions of the prosthesis can be made to fit, and thus to give a secure attachment to the whole prosthesis. Such small tube pedicles may be made for the upper, lower and the middle of the posterior borders of the prosthesis. Secondary defects under these tubes are closed by approximation. Underneath each of these tube pedicles extensions from the prosthesis fit, and allow it to be attached or detached at will by the patient without the use of possibly irritating skin glues. An alternative method of constructing these small flaps is not to tube them but to line the raw under-surface and secondary defect with split-skin grafts.

Tube pedicles

Secondary defects

(5) Correction of "bat ear"

Minor deformities

Minor degrees of "bat ear" are very adequately corrected by an excision, through a post-auricular incision, of an ellipse of conchal cartilage, together with a fairly generous removal of post-auricular skin. The wound is closed by a continuous subcuticular suture of six 0 catgut which does not have to be removed, which is a great advantage to children.

Major deformities

In other cases the deformity may be very marked, with the enlarged auricular cartilage forming a smooth hollow, lacking any of the normal convolutions. Here the procedure entails, in addition to the removal of a generous ellipse of cartilage from the conchal region, the making of a series of curved, parallel incisions in the remaining peripheral cartilage. When an appropriate amount of post-auricular skin has been removed and the wound closed, the reduced cartilage is squeezed into folds which, if the incisions have been made to the best advantage, closely reproduce the helix and antihelix convolutions of the normal ear.

3. TOTAL RECONSTRUCTION OF THE EAR

(1) Causes of total loss

The common causes of the total loss of the ear are given below.

(a) *Congenital absence*

Use of remnants

In cases of congenital absence of the ear there are generally remnants present which may be retained for repair of parts such as the lobule, the tragus or the rim. These congenitally absent ears often show other deficiencies of first arch development, particularly hypoplasia of the mandible on that side.

(b) *Traumatic loss*

Patients with traumatic loss of the ear comprise the largest single group currently seen. A large proportion of these cases are partial losses and the remaining normal parts can be of great value in obtaining a good appearance in the final result.

(c) *New growth*

In middle age

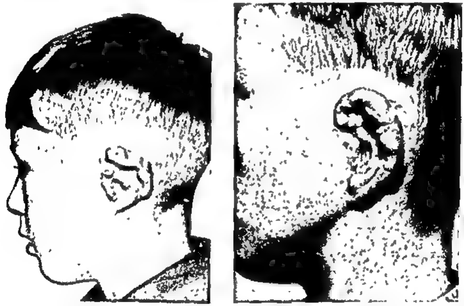
Destruction by rodent ulcers and epitheliomas accounts for the great majority of the cases of loss of ear seen in middle age and later. It is these

patients for whom a prosthesis is particularly suitable. Only a minority of these patients will consider the repeated operations necessary for the reconstruction of an ear to be worth while at their age.

(2) Principles of total repair

Congenital cases

The important feature of most congenital cases is that there is intact mastoid skin behind which a skeletal transplant can be placed and which will carry the transplant when turned forward, providing an outer skin to the re-made ear of exact match to the normal side. Maternal ear cartilage, when available, is the transplant which can give the most exact contour match to the normal ear (Fig. 150). This type of repair may be completed in 3–5 operations.



(*a*) (*b*)

FIG. 150.—Use of maternal ear cartilage in repair of congenital loss of external ear (*a*) Pre-operative condition, (*b*) maternal cartilage has been inserted behind the mastoid skin and turned forward to establish a retro-auricular groove lined by a free skin graft. Reconstruction is completed by ear rudiments and local skin flaps at later stages

Traumatic cases

For traumatic cases, what has to be provided is unscarred anterior skin cover of a good colour and consistency, and a match to the normal ear, with skeleton of appropriate shape, and posterior lining for the post-auricular groove, the whole combining to give an auricle with a meatus of normal patency and with the normal projection from the side of the skull. The anterior cover is again best obtained from the local mastoid skin when this is available, but there may be heavy scarring here and the first stage must be the excision of this scar tissue (Fig. 151). The raw surface is covered by a dermatome graft or full-thickness free graft if the base is soft and vascular, or by a flap or tube pedicle if, as is sometimes the case in wounds which have involved the skull, the base after excision is bony and unsuitable for the reception of a free graft.

First stage

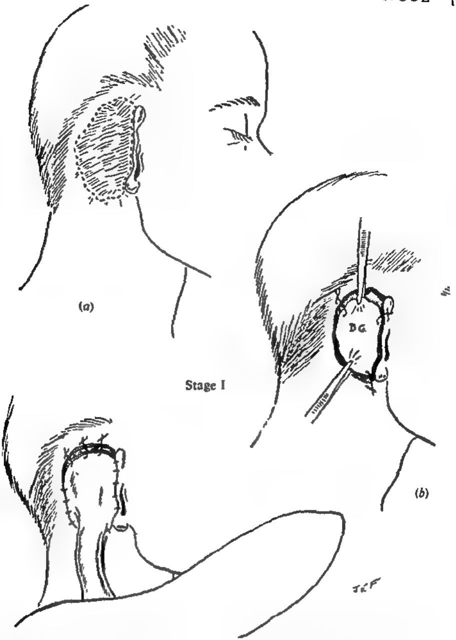
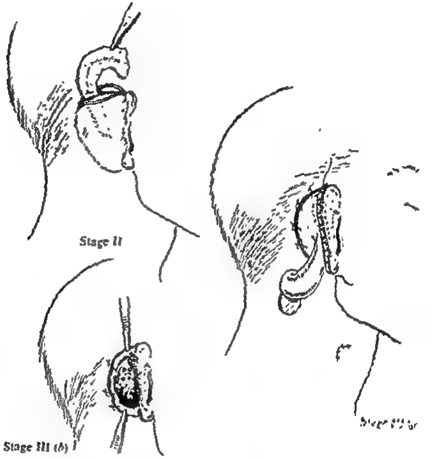


FIG. 151.—Principles of repair and reconstruction of ear Diagrams show preliminary stages necessary when mastoid region is unsuitable to turn forward as cover for ear Stage I (a) and (b) replacement of scar tissue by dermatome graft or full-thickness skin graft, (c) acromio-pectoral tube pedicle.

ond stage The next step is the insertion behind this skin cover of a suitably shaped skeletal substitute (Fig. 152, Stage II). At a later stage cover and skeleton are turned forward and the re-established post-auricular groove is lined by a tube *rd stage* pedicle or free graft (Fig. 152, Stage III). (Skeletal substitutes borne on transported tissues are less likely to survive or to stay *in situ* than are those *il stages* hinged on intact mastoid skin.) Still later, tragus, lobule, rim and concha can be better defined by local flaps, by a narrow marginal tube pedicle, and by excisions (Fig. 152, Stages IV and V).



Stage II

Stage III (a)

Stage III (b)

FIG. 153.—Reconstruction for traumatic loss of ear. Pre-operative condition.

(3) Technical points in operations

(a) Skin grafts

Matching

It is essential, when replacing scar tissue in the region of the future ear, that the graft or flap should be of thick, good-quality skin, and as close a match as possible to normal ear tissue. For this reason either a post-auricular graft from the opposite side or skin from just above or just below the clavicle is best. If a dermatome graft is used it should be a thick one from a hairless donor site.

(b) Skeletal substitutes

A wide variety of materials is available for use as skeletal substitutes. Foreign bodies which have been exactly constructed to the ear shape, such as acrylics or tantalum, are on the whole unsuitable, because sooner or later they tend to be extruded. As already mentioned, the transplant which gives the best appearance and end-result in successful cases is the maternal ear cartilage, but the simplest transplant is a single piece of cartilage shaped as a crook (Fig. 152). This cartilage may be autogenous, which is probably best from the point of view of permanence, but has the disadvantage that an additional dissection is involved, or human cadaver cartilage or preserved ox cartilage is used. Both these types of preserved cartilage graft are known to last for considerable periods in the human body. An interesting current technique of great promise is that described by Lyndon Peer (1943, 1948) in which diced autogenous cartilage is compressed in a perforated vitallium or tantalum mould into the shape of the auricle. The mould and contained cartilage are then embedded for a period of 6 months in the abdominal wall. During this period the diced cartilage becomes cemented into the exact shape of the auricle by organizing fibrous tissue. It may then be taken out, the mould removed, and the cartilage implanted behind the skin of the future ear site.

Extrusion of foreign bodies

Lyndon Peer technique

FIG. 154.—Same patient as in Fig 153 View of neck tube pedicle and pre-operative condition of ear.

An essential feature of the skeletal transplant is that it should have a well-marked conchal hollow if the

Conchal hollow

appearance of the reconstructed ear is to be a good one. A simple block of cartilage, shaped like a crook but with a sharply defined central deep hollow, gives an ear that projects off the head combined with a good conchal hollow, and an appearance that is as good as can be obtained by many of the more elaborate types of transplant.

(c) Post-auricular groove, tragus, crus and helix

When the transplant and skin cover are turned forward to re-establish the post-auricular groove, this is best lined with medium or thick dermatome *Post-auricular groove*

FIG 155—Implant turned forward, neck tube pedicle attached and spread around its rim and dermatome graft spread over the raw mastoid defect.

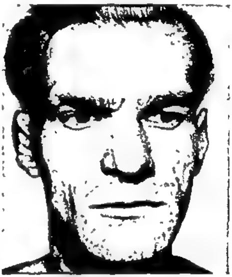


FIG 156—Same patient as in Fig 153. Post-operative condition, anterior view.

skin from the abdomen or other hairless part. It is sometimes worth while to turn forward some hair-bearing scalp if to do so will give a sufficient excess when folded on itself to form a good margin. Depilation may be obtained by later undermining and excision of the dermal layer; or this hair-bearing skin may be replaced by a free graft placed on to the fat that has been carried with it over the transplant. The tragus and the crus are best fashioned *Tragus and crus* from local flaps of posterior cheek skin which may be lined on their deep surfaces with free skin grafts (Fig. 152); the helix can often be provided by *Helix* the attachment round the rim of a long narrow tube pedicle, raised and transferred from the neck in multiple stages.

PART II
RECONSTRUCTION OF THE NOSE

1. PARTIAL RECONSTRUCTIONS OF THE NOSE

(1) Skin cover

288.] A free graft may be used in those cases in which the loss is limited to skin and subcutaneous tissues. Losses involving the skeleton and lining as well as the cover need repairs by flaps borne on pedicles.

Donor site The donor site for a free graft which gives the closest match to normal nasal skin is post-auricular skin. This is cut to a pattern of the defect, after excision of the scarred or keloidal area, and sewn with interrupted fine silks into place Pressure is maintained by pressed wool for six days. When post-auricular skin is not available the skin from above or below the clavicle, which is a good match to facial skin, may be used as a donor site. In women, in whom scars about the clavicle are undesirable, a medium thickness dermatome-cut graft from a hairless donor site may be used. Skin from the inner side of the arm is almost invariably too pale for use as a graft on the nose.

(2) Nasal skeleton

Skeletal reconstructions are used for correction of three chief types of deformity: (a) uncorrected nasal fractures; (b) a "hooked" deformity; and (c) the grossly enlarged nose with bulbous tip.

An essential feature of all these reductions is that they are done by intranasal approaches without external scarring. The operation for all three types of deformity entails the mobilization of the nasal skeleton from maxillary, septal and frontal attachments, plus the mobilization of alar cartilages from *Para-marginal intravestibular incisions* overlying skin. These two procedures are done through *para-marginal* intravestibular incisions which are undermined, and may be carried laterally to give approach to the margins of the piriform fossa. The bony divisions are done with saw [illegible] is the re-
moval of the h[illegible] tila-
[illegible] are
ginous septum [illegible]

then done as may be necessary in individual cases to complete the straight bridge line, to give a shorter nose, or a thinner, narrower nasal tip.

The operations may be done under a local anaesthetic, but general anaesthesia is preferred by most patients. Infiltration of the nasal tissues with Novocain-penicillin and adrenaline is advisable even when a general anaesthetic is used. A plaster-of-Paris splint running from forehead across the nasal bridge is the most efficient post-operative fixation. It is maintained for 7–10 days. The airway is maintained by greased small rubber tubes passed *Anaesthesia* *Maintenance of airway*

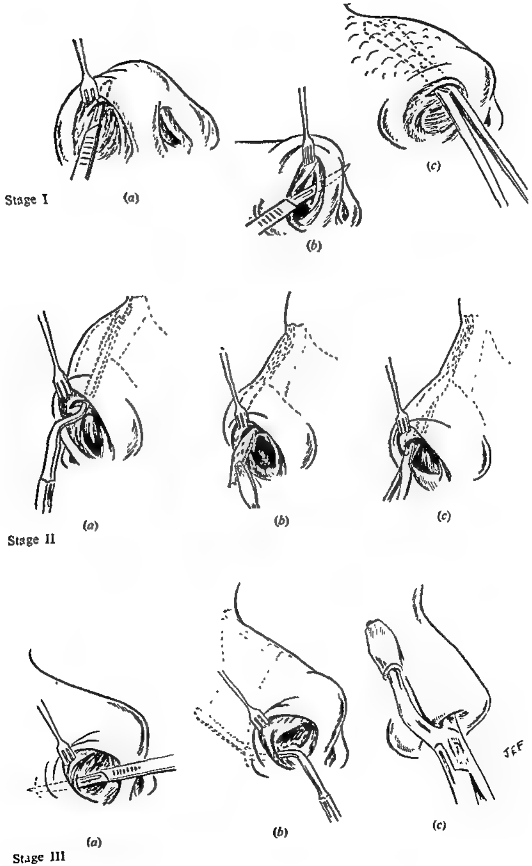
FIG. 157.—Reduction of old broken nose by mobilization and reduction of nasal skeleton, shortening of septum, remodelling of alae and a cartilage implant.

into the nasal pharynx. As in all other cases with the use of plaster of Paris, pressure sores are by no means unknown and should be specially guarded against.

In a certain proportion of cases the best bridge line will only be obtained by the insertion of a cartilage strut along it (Fig. 157). In a few cases it is not practicable to do this at the primary operation as the excisions of the lining may prevent the preparation of a suitable bed for the implant. Autogenous, preserved cadaver or ox cartilage may be used. The preserved ox cartilage has the advantage of convenience; it appears to persist in the tissues well and with less distortion than fresh autogenous cartilage. *Insertion of cartilage strut*

(3) Lining losses

The classical condition for which a repair of lining is needed is the tertiary syphilitic deformity. This saddle-shaped nose is caused by a loss of both skeleton and lining. The destroyed and scarred mucosa needs replacement by an extensive epithelial inlay. For this the nasal cavity is approached through an incision in the buccal sulcus above the incisor region. The scar tissue in vestibule and underlying nasal skin is excised. A free split-skin graft borne on a gutta-percha mould, supported by an appliance to a cast-metal splint on the upper teeth, is then inserted. Subsequently a prosthesis is borne on an *Incision in buccal sulcus* *Prosthesis*


Stage I
(a)
(b)
(c)
Stage II
(a)
(b)
(c)
Stage III
(a)
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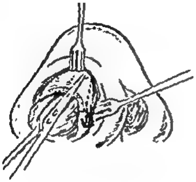
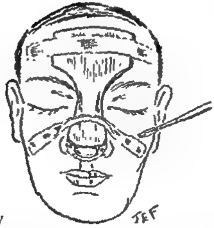
JEF



(a)

(b)

Stage IV (c)



Stage V

FIG. 158.—Schematic representation of operative stages in reduction of nasal deformity Stage I. (a) and (b) Bilateral para-marginal intravestibular incisions through which triangular cartilages, septal cartilage and upper excess of alar cartilages are mobilized from skin, (c) mobilization of skin and subcutaneous tissue from whole of nose above vestibular incisions. Stage II. (a) and (b) Removal by saw of humped or depleted bridge line; (c) removal by scissors of septal portion of bridge line below bony hump. Stage III. (a), (b) and (c) Infracture margins of piriform fossae are exposed through stab incisions above base of the alar cartilages, tunnel cleared by elevation along outer surface of fronto-nasal process up to the inner canthus; the saw divides bone along this line, infracture is completed by Walsham's forceps Stage IV. (a), (b) and (c) Excess of lining above incisions is removed by triangular excisions to make a symmetrical fit to smaller nose size. Columella may need shortening to bring up drooping tip. Raw edges are best sutured with fine catgut. Stage V The tip is supported by a horse-shoe of strapping. The

upper denture and, through the naso-buccal fistula in the sulcus, supports the nasal framework to give a normal nasal contour.

Cartilaginous implant

Some minor nasal deformities of the syphilitic type may, however, be corrected by other means than by a prosthesis borne on a denture. A simple cartilaginous implant introduced along the bridge through a columella incision may suffice to give a good straight bridge line. The hinged cartilage graft which restores the bridge and supports the tip may be used instead. It may be used for syphilitic deformities when the lining loss is not predominant or in cases of cartilage loss after septal abscesses. These grafts along the bridge line, whether cartilage, bone, or foreign body, are inserted through a

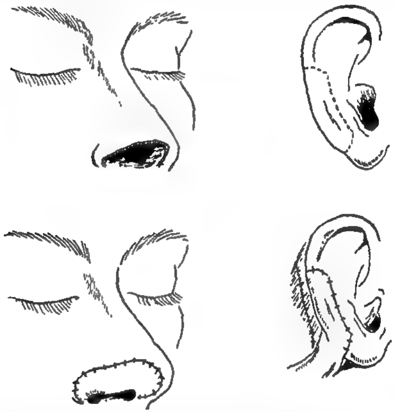


FIG 159.—Repair of alar defect by composite ear graft. Free graft from ear margin is cut to pattern of nasal defect and sutured into position Secondary ear defect repaired by local mastoid flap.

central columella incision Good implantations—bone or cartilage—into the nose improve the airway.

(4) Nasal tip

Distant flaps

Free grafts

Major losses of the tip and alae are generally repaired by flaps from a distance, particularly from the forehead; but many less extensive cases can be given a very satisfactory repair in one operation by a composite free graft from the lobule or ear margin. The skin of the margin of the defect is excised; a composite graft from the lobule is cut to pattern to give a satisfactory tip, and is then sutured in place by multiple fine silks (as for alar repairs).

(5) Alae

A variety of local and distant flaps are available for the repair of alar losses. These include forehead, nasolabial, and tube pedicle flaps from a distance. It is, however, possible to repair many alar losses in one operation by composite free grafts from the ear margin (Fig. 159).

In other cases it may be possible, after undermining it, to roll the retracted lower margin down and to fill the upper defect with full-thickness free grafts; at the same operation the septum may be shortened to raise the columella into line with the prepared alar.

(6) Columella

Certain partial losses of the columella, such as are seen after small missile wounds, can also be repaired by composite grafts of lobule or ear margin. In major losses of the columella the following method is recommended. Alar flaps are used from each side; each flap is based above and swung into the midline (with shortening of the alae) to meet in front of the lower end of the septum. At later stages the central crease and the margin of the ala and tip are revised. The result is a shorter nose than the original, but a very life-like reconstruction of the columella can be obtained. *Alar flaps*

(7) Bridge and upper nose

The problem here may be restoration of lining, skeleton and cover, or simply of cover and skeleton. When the lining is needed it is commonly found by inturned (local trapdoor) flaps. This increases the size of the cover defect and for this reason many of these defects are best repaired by tube pedicles borne on the arm. Alternatively the forehead may be used, at the price of some forehead scarring. In the first instance an excess of tissue is let in; later the skeletal defect is repaired by cartilage or bone implant. At a third stage it may be necessary to remove the excess of soft tissue, model the bridge line to normal shape, and revise scars. *Local flaps*

2. COMPLETE NASAL RECONSTRUCTIONS

(1) Principles

It must be emphasized that the complete reconstruction of a nose that has been totally lost leaving a defect level with the cheeks is a major surgical procedure. The operation has to be done in a number of stages in which there is an irreducible element of hazard, so that even the most experienced plastic surgeons number amongst their successes nasal reconstructions in which, after a series of operations, the appearance is short of the original goal. *Element of hazard*

The problem is the restoration of lining, of skeleton and of cover, for the whole nose, to give a feature with the normal projection from the plane of the face and with an airway of full patency.

In many cases of partial reconstruction of the lower and anterior half of the nose, the lining may be provided by inturning local cheek flaps. This method, however, is seldom practicable for a total reconstruction of the nose. For such total reconstruction the lining is often better provided on the under-surface of the covering flap before it is brought into the nasal position. There are, too, some advantages in incorporating the skeleton of the bridge *Partial reconstruction* *Total reconstruction*

line, or the major part of it, in the cover flap before it is carried into the nasal position. If this is not done at this stage, that is if the tissues are placed over the nasal defect without skeletal support, they commonly come to lie very flat on the face; it may then be impossible to produce an adequate degree of

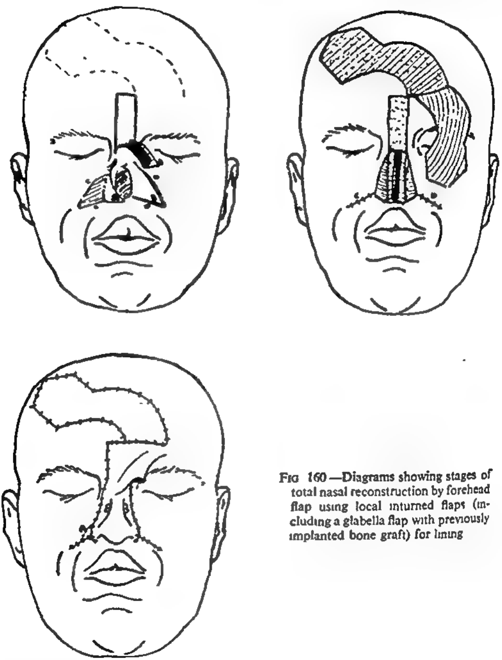


FIG 160—Diagrams showing stages of total nasal reconstruction by forehead flap using local inturned flaps (including a glabella flap with previously implanted bone graft) for lining

elevation of the nose, no matter how much bone or other skeletal transplant is inserted into the soft tissues at later stages.

(2) Choice of method

The earliest methods of nasal reconstruction were the Hindu method (Fig. 160), in which a forehead flap is used, and the Tagliacotian method

which utilizes a flap from the inner side of the arm. These remain the two chief methods in practice today. Advantages of the forehead flap are clear; it is a good colour and texture match to normal nasal skin; it is readily modelled to give an approximate tip and alar form; it can be brought down into the nasal position in one stage. Its disadvantages are equally apparent; there is not much of it; in many cases of total loss a narrow or a scarred forehead prohibits the use of the method. Furthermore a forehead flap means that there are donor site scars in a prominent position. A certain proportion

Forehead flap

(a)

(b)

FIG. 161.—Total nasal reconstruction by forehead flap using local inturned flaps (including a glabella flap with previously implanted bone graft) for lining; (a) and (b) pre-operative condition.

of these forehead rhinoplasty scars may be rendered quite unnoticeable by later scalp plastics; but in general some permanent, and occasionally prominent, scarring is the price paid for a forehead rhinoplasty (Figs. 161 and 162). In contrast the inner side of the arm provides an inconspicuous donor site, and tissue in considerable abundance. On the other hand it is not of the same texture or colour as facial skin, and although, with exposure to the sun, arm skin may blend in very satisfactorily, this does not always happen. Midway between arm and forehead as a donor site for cover, both as regards tissue match and amount of tissue available, is the lower neck skin, which may be transported to the nasal region as a tube pedicle. It is particularly suited to partial nasal reconstructions in men. In women, donor site scars about the clavicle should be avoided.

Flap from inner side of the arm

Lower neck skin

Although forehead and arm are the chief donor sites for nasal reconstructions, non-hairy tissue from any part of the body may be used as cover. The tissue can be transported from chest or abdomen as tube pedicles, either direct or borne on the arm.

Tissue from chest or abdomen

(a)

FIG. 162.—Total nasal reconstruction by forehead flap using local inturned flaps (including a glabella flap with previously implanted bone graft) for lining; (a) and (b) post-operative condition. The lip has been lengthened and brought forward by bilateral fan flaps and the secondary defect on the forehead has been repaired by scalp plastic (c).

(b)

(c)

The lining in total reconstructions is best provided for the flap before, or as, it is swung over the nasal position (Figs. 163–7).

Associated losses

Losses of cheeks and lips

Many of these total nasal losses have associated losses of cheek and lips which need a tube pedicle reconstruction. For these cases lining is given to the rhinoplasty flap by a tube pedicle—abdominal if a woman or thoraco-acromial if a man. This may be attached to the under-surface of the forehead flap at an early period, or at the time it is swung into the nasal position. When lining and cover flaps are attached early, a skeletal strut along the future bridge line may be inserted between them; or this graft may be inserted deep to the covering rhinoplasty flap before the lining flap is attached. At a later stage cover and lining flaps with enclosed bone graft can be swung into the nasal position and attached there. At an interval of 2–4 weeks the pedicles are divided, leaving a considerable excess of tissue at the nasal site for later modelling of tip and alae. It should be remembered that tube pedicles will stretch during the period of attachment, and that some retraction will take place as the skin recovers its normal tone. If a bone or cartilage graft has not been inserted in the flap before it is placed in the nasal position, this has to be done later; the difficulty then is that the soft tissues have flattened, being without skeletal support, and it may be difficult to elevate them sufficiently for a normal bridge line. In those cases in which skeleton has been inserted previously, further onlay grafts of bone or cartilage may be necessary to give a normal prominence to the nose.

Division of pedicles

(3) Technical points

(*a*) *Forehead rhinoplasty*

The minimum forehead tissue necessary for a nose is an area of 7×5 centimetres, but more is desirable for most cases of total loss of nose. This tissue may be borne either on an oblique pedicle, in which case it is best "delayed", or an up-and-down pedicle of the Gillies type. Columellar and alar form may be produced by inverting the margins as in reconstructions for partial nasal losses when lining is obtained from the local cheek flaps, but such alae are commonly thick and clumsy. Better appearance is obtained by previously inserted chondro-cutaneous grafts into the forehead at the future alar sites.

Chondro-cutaneous grafts

FIG 163—Total nasal reconstruction by forehead flap using tube pedicle tissue for lining. Pre-operative condition, showing bomb damage to face, affecting nose, upper lip and forehead (Primary treatment by Professor Bentley.)

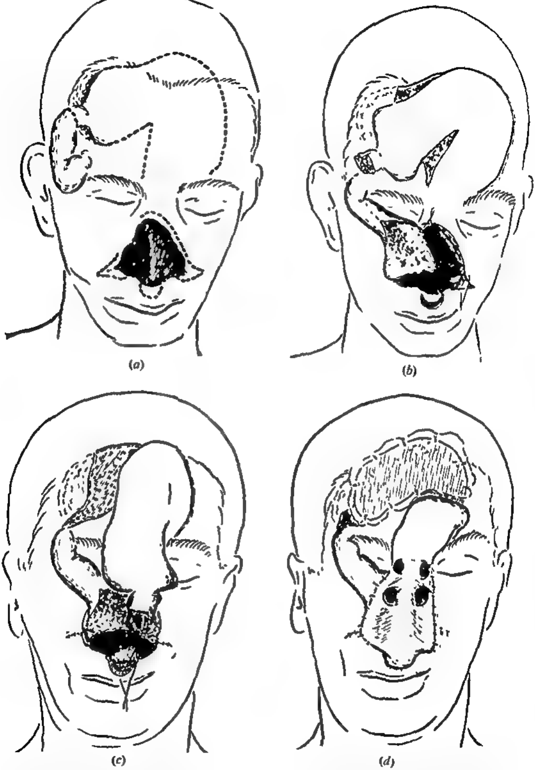
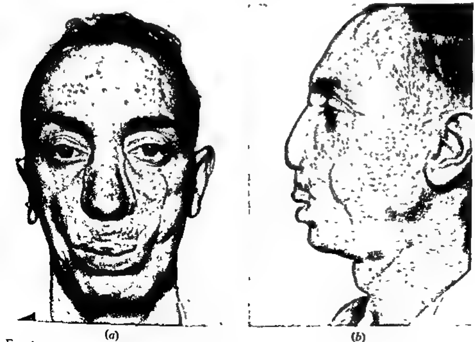


FIG. 164.—Total nasal reconstruction by forehead flap using tube pedicle tissue for lining. Diagrams show (a) and (b) the acromio-pectoral tube pedicle has been raised and brought to forehead, where it first provides lining for the future columellar region. In main

FIG 165.—Total nasal reconstruction by forehead flap using tube pedicle tissue for lining. Acromio-pectoral tube pedicle for lining, in intermediate attachment behind ear, before being carried to forehead Lip already repaired by bilateral fan flaps.

FIG 166—Total nasal reconstruction by forehead flap using tube pedicle tissue for lining. Covering forehead flap and lining tube pedicle in nasal position



(a) (b)

FIG. 167—Final results of total nasal reconstruction by forehead flap using tube pedicle tissue for lining, including repair of forehead secondary defect.

(b) Tagliacotian or arm rhinoplasty

Elevation of flap

This arm flap has a distal base. It must therefore be elevated in stages. A rectangular flap 12 centimetres long and 9 centimetres wide, attached at both ends, is raised on the inner side of the left arm. It is re-sutured into place and left for 2–3 weeks. The proximal attachment of the flap is then raised and the flap elevated throughout its whole extent before being sutured back into place. Three weeks later the flap may be elevated and attached to the nasal region. The secondary arm defect is covered by a split-skin graft. Here again if the root of the nose remains it may be possible to obtain lining from in-turned cheek skin flaps. The arm attachment is divided 2–3 weeks later, leaving an excess of arm tissue on the nose for subsequent modelling of alae and columella.

Covering of arm defect

Total reconstructions

When the arm is used for total reconstructions the flap is delayed as above, but it has to be lined by a tube pedicle tissue either at the time it is swung into position on the nose, or before. The skeletal implant may be inserted under the cover flap before the combined flaps are swung into position. An alternative method is to insert it under the skin of the glabella region and delay this flap here; then when the arm flap is swung into the nasal position the glabella flap and bone graft are turned down as a trapdoor to provide some lining and with the bone on its upper surface. Whichever method is used, considerable excess of soft tissue should be left at this stage. Further bone implants may be needed to give a proper nasal profile.

REFERENCES

Peer, A. Lyndon (1943). *Arch. Otolaryng., Chicago*, 38, 171.
— (1948) *Plast reconstr. Surg*, 3, 653
[References to other titles are given under Reconstruction of the Ear and Nose, in the Index volume.]

RECTUM—BENIGN TUMOURS OF

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289.] A benign tumour of the intestine seldom causes symptoms until it has assumed the shape and form of a polypus. The word polypus or polyp is a general term used to describe any pedunculated tumour whatever its nature. Most polypi prove to be either inflammatory lesions or non-malignant tumours, but an unsuspected focus of malignancy may sometimes be revealed by the microscopic examination of a pedunculated adenoma.

It is not difficult to explain why benign tumours tend to become polypoid whereas malignant ones do not. A benign tumour at first consists of a small well-defined nodule embedded in the bowel wall but as it increases in size it tends to project from the surface because there is more freedom for expansion in this direction. Gradually it becomes pedunculated owing to the pressure of peristaltic contractions and the traction exerted by the contents of the intestine. Malignant tumours on the other hand, even though they may at first project into the lumen of the bowel, do not become extruded in this way because they are anchored to their site of origin by marginal infiltration into surrounding structures. It is useful to remember that a tendency to develop a polypoid shape is common to all types of benign tumours whereas for the most part malignant tumours tend ultimately to assume the form of ulcers.

1. EPITHELIAL TUMOURS

Two varieties of benign epithelial tumour occur in the intestine; they are the adenoma and the villous papilloma. Both arise from the glandular epithelium and as they grow each develops a distinctive appearance. An adenoma is at *Adenoma* first a round firm sessile tumour, the surface of which is smooth or slightly nodular and darker in colour than the surrounding mucosa. As the tumour

enlarges it develops a pedicle which gradually elongates until it reaches even an inch or two in length. The stalk may be *flattened from above downwards* so that the tumour is suspended by a strap-like attachment. If a pedunculated adenoma is cut open it will be seen that the stalk contains no tumour tissue but only a prolongation of the mucosa and submucosa containing blood-vessels and connective tissues.

Villous papilloma

In contrast with this a villous papilloma is usually much larger. The growth has a characteristic convoluted appearance and is more raised in the centre than at the margins, which may be *only slightly elevated above the surrounding mucous membrane*. Close inspection of the surface reveals a mass of delicate villi giving the tumour a velvety appearance. Villous papillomas are much less common than adenomas and are rarely found elsewhere than in the rectum and pelvic colon.

The striking difference in gross characters of these two epithelial tumours is reflected also in their histology.

In villous papilloma the *mucus-secreting epithelium covers the outside of* the central supporting core of connective tissue and blood-vessels, the secretion being poured out on the surface whereas in an adenoma the secreting cells are arranged as in tubular glands, mucus being discharged into a confined space. It would seem that a villous papilloma arises as the result of the proliferation of surface epithelium whereas an adenoma *follows the* neoplastic growth of epithelium in the depths of the intestinal crypts.

The close relationship between benign epithelial tumours and malignant growths of the intestine is well known. As evidence the following points may be mentioned.

(1) When patients with adenomas or papillomas of the rectum have been kept under observation over a period of years it has frequently been *found that carcinoma has developed in a tumour previously known to be* non-malignant.

(2) It is not uncommon to find a small focus of carcinoma in a tumour, the greater part of which has the histology of an adenoma or villous papilloma. The carcinoma has developed in a pre-existing benign tumour.

(3) Similarly at the edge of a frank carcinoma a *careful search may* reveal surviving portions of a benign tumour, the last remains of the *forerunner of malignancy*.

(4) Familial polyposis, a rare disease in which the whole mucosal surface of the colon and rectum is covered with adenomatous tumours, is almost invariably followed by intestinal cancer and in this disease the first *foci* of malignancy are nearly always found in an adenoma or papilloma.

These facts justify the conclusion ... should be regarded as a precancerous lesion. ... inevitably become malignant or ... adenoma or papilloma. These lesions are described as precancerous because cancer often develops within them.

Evidence of malignancy

The first indications of malignancy are darker colour and more solid consistence. Ulceration and induration of the base of a tumour are *later and* more certain signs of malignancy and when these are present the microscope

...tion and ...ion

seldom fails to confirm the clinical diagnosis of carcinoma. A careful study of the histology of the tumour may be necessary to decide whether or not an adenoma has become malignant. There is no characteristic change in the size, shape or staining of the carcinoma cell which distinguishes it from a rapidly proliferating cell in an adenomatous polypus, but the onset of malignancy is recognized most certainly by the relationship of the proliferating epithelium to surrounding tissues, and especially by what is called infiltration. *Infiltration* However, this alone is not enough, because it sometimes happens that collections of epithelium may become misplaced or may appear to be invading because of the way in which the section has been cut. The surest evidence of malignancy is provided by the combination of infiltration with atypical cellular characters. Carcinoma cells are less columnar and more globular in shape than the epithelial cells of benign tumours and their nuclei are larger, rounder and more irregularly stained.

Attempts have been made to divide adenomatous polypi into groups with *Classification of probable malignancy* a view to distinguishing different degrees of probability of the onset of malignancy, but these have proved to be unsatisfactory in practice. All that can be done in most cases is to say whether or not there is evidence of active epithelial proliferation. This is shown by the fact that the epithelial cells are more closely packed together, the nuclei stain more deeply and occupy more of the cell, and there is little if any secretion of mucus. Applying these standards, adenomatous polypi may be divided into two groups: (1) those which are in a quiescent condition and (2) those undergoing active proliferation. It is in the second group that carcinoma is most likely to develop.

2. CONNECTIVE-TISSUE TUMOURS

Benign connective-tissue tumours are rare, and only fibroma, myoma and lipoma need to be mentioned. Fibromas arise either from the loose connec- *Fibromas* tive tissue of the submucosa or from the sheaths of nerves. They develop into dense rounded encapsulated tumours which sooner or later become pedunculated. The cut surface shows a whorled appearance. Myomas resemble *Myomas* fibromas and can be distinguished only by microscopic examination. Lipomas *Lipomas* may arise from either the submucous or the subserous coats and appear as round polypi covered with intact mucosa. If the tumour is sliced open the interior is seen to be composed of adipose tissue.

3. VASCULAR AND LYMPHATIC TUMOURS

A massive cavernous haemangioma may occur in the colon and give rise to persistent bleeding. It causes great thickening of the wall of the bowel which is dark red through engorgement with blood. The lesion may extend over several inches of the colon and be accompanied by similar malformations in the blood-vessels of the mesentery.

Tumours composed of lymphoid tissue may arise from the lymphoid follicles which lie in the submucosa. In its gross characters a lymphoma *Lymphomas* closely resembles an adenoma but is easily distinguishable by microscopic examination because it is composed entirely of lymphoid tissue with a layer of mucous membrane covering it.

4. LESIONS RESEMBLING BENIGN TUMOURS

The only lesions of the intestine likely to be mistaken for benign tum inflammatory polypi and cysts.

Inflammatory polypi

Any form of chronic ulceration in the intestine may be followed by s inflammatory polypi. They are met with most frequently after ulcerative colitis or dysentery. If the polypi are scattered over a w the condition is described as pseudo-polyposis to distinguish it fr polyposis.

Inflammatory polypi differ from benign epithelial tumours in bei irregular in size and shape and in showing a more patchy distr Moreover, the intervening mucosa is usually pale and atrophied a show scars and furrows indicating healed ulceration. The polypi co tufts of granulation tissue and surviving tags of mucous membrane regenerative hyperplasia is in progress it may be difficult even by sec distinguish this from true adenoma. The distinction is important l inflammatory polypi do not tend to become malignant whereas adenor

Condylomas

The secondary lesion of syphilis known as condyloma may bear som resemblance to a benign tumour when arising from the perianal sk the primary and tertiary lesions of syphilis are more likely to be mista malignant tumours.

Anal warts

Simple anal warts, non-specific in origin, have a rough fissured appea they are usually multiple and may surround the anus and extend i anal canal. They are sometimes known as condylomata acuminata (m a protuberance covered with sharp points), but this term may lead t fusion with syphilitic condylomas. "Anal warts" is a better descriptive

Fibrous polypi

The term fibrous polypus is used to describe hard pedunculated arising in the ano-rectal region. They are derived most commonly thrombosed haemorrhoids but may arise also from hypertrophied papillae. Fibrous polypi consist of a central core of fibrous tissue cove squamous epithelium and may protrude from the anus and resem neoplasm.

Cysts

Cysts of the colon, rectum and perianal region are rare. Some are cong in origin and are due to persistence of vestigial structures; cysts ma result from implantation by trauma or surgical operations.

A congenital cyst may occupy any part of the intestinal wall (intramus submucosal or subserosal). The term colitis cystica is used to descrit presence of large numbers of cysts in the submucosa and mucous meml of the colon.

Cysts between the rectum and sacrum have been attributed to persistence of vestigial structures such as the post-anal or tail gut an neurenteric canal.

The importance of the tail gut and neurenteric canal as an origin for and fistulae has been exaggerated. Most of the cases so described are likely to have been dermoid cysts or teratomas.

Implantation or inclusion cysts originate from epithelium displaced trauma or surgical operation. In the rectum they may give rise to les resembling sessile adenomas. On section a submucous implantation appears as a cystic space filled with mucus and lined with mucus-secre

columnar epithelium. The histological diagnosis presents no difficulty if the possibility of such a lesion be kept in mind and if the fact of previous operation or injury be known.

5. SURGICAL TREATMENT OF BENIGN TUMOURS

Adenomas of the lower half of the rectum are frequently pedunculated and, under anaesthesia, can be delivered through the anus by hooking the finger round the pedicle or, alternatively, by placing a forceps upon the pedicle through a rectal speculum. The pedicle can now be ligated with No. 16 hollow woven silk and the adenoma can be excised In those cases in which the pedicle is broad, Goodsall's method of transfixion ligature is advisable (*see* Fig 204, p 380).

Goodsall's ligature

(1) Pedunculated adenomas

Pedunculated adenomas in the upper half of the rectum can occasionally be made to prolapse through the anus, but are usually more easily removed through an operating sigmoidoscope using a Frankfeldt's diathermy snare or a crocodile forceps insulated with rubber tubing. The snare or forceps should be held away from the wall of the bowel when applying the diathermy current.

Frankfeldt's diathermy snare

(2) Sessile adenomas

Sessile adenomas are treated by fulguration with a diathermy electrode through a proctoscope or through an operating sigmoidoscope. A fairly low cutting current is used in all cases to avoid the risks of coagulating too deeply. Adenomas situated on the anterior rectal wall above the peritoneal reflection should be treated with greater caution, and it is safer to deal with these cases in two or more sessions at fortnightly intervals than to run the risk of perforating the rectum.

(3) Pedunculated and sessile adenomas

In some cases part of the tumour may be pedunculated and the remainder sessile, and in these the pedunculated portions should be removed with the diathermy snare before fulgurating the sessile portions.

These cases should all be examined at later intervals to ensure that the whole of the tumour has been removed and also to detect any recurrence; all portions removed should be examined histologically to make certain that malignant change has not taken place. Should there be any suspicious areas, periodic examination of the site must be undertaken for several years.

Periodic examination

(4) Villous papillomas

Villous papillomas of small or medium size occurring in the lower part of the rectum can usually be delivered through the anus by traction upon the mucous membrane at their base with a sponge-holding forceps, thus producing a false or artificial pedicle which can then be ligated by Goodsall's method Traction upon the papillomas is inadvisable, because they are extremely friable and considerable bleeding may occur. Papillomas of similar size on the upper part of the rectum are removed through an operating sigmoidoscope by multiple diathermy snaring, and by final fulguration of the base, this process may require several sessions.

Haemorrhage

(5) Villous tumours

Resection

Large villous tumours, because of their size, are unmanageable by the above methods. Since they tend to become malignant, some form of resection, either a combined excision or, preferably, a restorative resection when possible, is necessary. Should the case be suitable for a restorative operation it is well to remember that these tumours are frequently multiple and any smaller tumours should be dealt with first by the diathermy snare.

(6) Familial polyposis

There are three methods commonly employed for dealing with familial polyposis, a fortunately rare but distressing condition.

Ileostomy

The first method is the complete removal of the whole colon and rectum, leaving the patient with a terminal ileostomy. This is the only method of ensuring absolutely that no malignant disease can develop. An ileostomy, however, is not entirely free from complications apart from the inconvenience of wearing a suitable apparatus to collect the semi-fluid motions.

The second method is combined excision of the rectum and pelvic colon. This is carried out on the grounds that malignant changes usually occur more early and more frequently in the rectum and pelvic colon. The remaining colon must then be examined radiologically at intervals of 6 months in order to detect any malignant change in any of the colonic polypi. This is not entirely satisfactory, since a malignant tumour may reach a considerable size before it is recognized by x-ray examination.

Diathermy

Thirdly it is possible in most cases to remove the adenomas from the rectum by diathermy. All the polypi should be removed to a distance of 15 centimetres. Multiple sessions are required and the task may take weeks to accomplish.

Sigmoidoscopy

The whole colon can now be resected in one stage and an ileo-rectal anastomosis made below the uppermost margin cleared of polypi. This leaves a rectal stump which can be palpated and examined by direct vision through a sigmoidoscope. This examination must be undertaken without fail every 3 months and later at 6-monthly intervals. It has been successfully carried out in a number of cases and some patients are alive and well after over 25 years.

These patients have 3 or 4 bowel movements each 24 hours but have normal and complete control. It will be found that further polypi do not appear to grow so vigorously in the ileal contents and, provided regular follow-up examinations are made, removal by diathermy would appear to be the best method.

[References to other titles are given under Rectum—Benign Tumours of, in the Index Volume.]

RECTUM—CARCINOMA OF

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1. INTRODUCTION

290] Carcinoma of the rectum and colon offers a better chance of surgical cure, especially when diagnosed early, than growths in any other part of the digestive tract.

2. AETIOLOGY

A large majority of carcinomas of the rectum arise in a pre-existing benign tumour or in an area of hyperplasia. It is often found that a carcinoma of the rectum is associated with multiple areas of hyperplasia or even with a benign tumour. For this reason multiple primary carcinomas are not uncommon in this portion of the bowel.

Sex and age

Carcinoma of the rectum occurs most commonly in the fifth decade and is approximately twice as common among men as among women.

3. PATHOLOGY

(1) Site

Carcinoma occurs in the rectum at any site, with equal frequency.

(2) Types

Hypertrophic *Ulcerative*

For practical purposes there are two main types of growth, the hypertrophic, which is usually of a low or average grade of malignancy, and the ulcerative, which is often of a higher grade (Broders, 1925).

(3) Spread

Extension through bowel wall

A carcinoma spreads in a centrifugal manner but spreads more rapidly around the lumen of the bowel than it does in an upward or downward direction. As it increases in size it extends through the bowel wall and finally invades the extra-rectal tissues and lymphatic glands, and at any time a vein may be involved, though this occurs most commonly in advanced cases.

(a) Dukes's classification

At St. Mark's Hospital, Dr. Cuthbert Dukes has classified carcinomas of the rectum in terms of local spread and lymphatic involvement. He divides them into A, B and C cases. A cases are those in which the growth is limited to the bowel wall (15 per cent), when the extra-rectal tissues are involved the growth is classified as a B case (35 per cent), and when finally the lymphatic glands contain metastases the specimen is classified as a C case (50 per cent).

(b) Lymphatic spread

The spread is first in an upward direction along the superior haemorrhoidal and inferior mesenteric vessels. In a large majority of cases it is only when these upward lymphatics are blocked that there is downward or lateral spread.

(c) Venous spread

Involvement of the liver

Venous involvement and spread to the liver is unpredictable and may occur at any stage of the disease. Anaplastic and rapidly growing tumours invade the veins more frequently, hence a small anaplastic growth may have extensive hepatic metastases.

4. CLINICAL FEATURES

Early symptoms

The early symptoms of carcinoma of the rectum are usually very slight, though bleeding occurs as a first symptom in about 80 per cent of cases. Careful examination is therefore necessary in all cases of rectal bleeding, however slight. Alteration in bowel habit develops as the tumour increases in size but, in the early stages, may be extremely slight and overlooked by the

Bowel habit

patient. It is only by careful questioning that slight alterations in defaecation may be elicited. Frequent bowel actions, and alternating constipation and diarrhoea with cachexia are late symptoms. *Late symptoms*

5. DIAGNOSIS

The large majority of carcinomas of the rectum can be felt with a finger in the rectum or palpated through a fold of mucosa. Bi-manual pelvic examination will often reveal high growths. Following physical examination, sigmoidoscopy should be carried out in all cases. This will enable the diagnosis to be confirmed by biopsy of the tumour or of any suspicious indurated area. It will also enable the surgeon to inspect the recto-sigmoid region and lower pelvic colon—regions difficult to visualize on barium enema examination even when oblique views are taken. *Physical examination* *Sigmoidoscopy*

6. DIFFERENTIAL DIAGNOSIS

Though, as a rule, there is little difficulty in arriving at the diagnosis of carcinoma of the rectum it should be remembered that certain inflammatory conditions and other malignant tumours may simulate an adenocarcinoma in this region. The induration following submucous injections for haemorrhoids, inflammatory stricture, submucous abscess or the granulomas may simulate a carcinoma. Among the granulomas, an amoebic granuloma must be remembered especially since World War II. Soft innocent tumours, such as an adenoma or a villous papilloma should be carefully examined, since a portion of such a tumour may be undergoing malignant change. The rectal wall may be involved by infiltration of tumours from without; namely endometriosis or carcinomas of the stomach, ovary or prostate. Squamous-cell carcinoma is usually situated in the anal canal or anus, but may occur higher in the rectum. Sarcoma of the rectum is rare, but may lead to difficulties in diagnosis. To distinguish these conditions biopsy is often the only method, but in cases of doubt examination under an anaesthetic, or exploratory laparotomy, may be necessary. *Conditions simulating carcinoma* *Sarcoma*

7. PRE-OPERATIVE TREATMENT

The patient should be admitted into hospital at least 5 days before operation. Low residue, high protein diet is given and attention paid to fluid, salt and glucose intake. Complete physical examination is carried out, the blood chemistry (plasma chlorides, protein, blood urea), blood count and blood group are estimated, and, in certain cases, electrocardiography and other investigations may be necessary. Blood transfusion is not infrequently necessary in these cases and must be carried out if the haemoglobin is below 75 per cent. For 5 days before operation phthalyl-sulphathiazole, 10 grammes, is given in divided doses every 24 hours, together with vitamin B complex and vitamin C in full doses. Chronic obstruction is overcome by the use of milk of magnesia and liquid paraffin in addition to a daily high lavage or enema. The last enema should be given on the evening preceding the operation. If a constricting growth is present, decompression may be aided by the passage of a rectal tube through the growth either with a finger or by means of a sigmoidoscope. If adequate decompression fails, then, and then only, is a preliminary colostomy advised. *Diet* *Blood transfusion*

(1) Colostomy

Colostomy has little place in the palliative treatment of cancer of the r
except for the relief of acute obstruction. Excision of the primary gro
the only satisfactory palliative treatment for a carcinoma in this r
When the primary tumour is removable it should be excised even in the
ence of hepatic metastases or local peritoneal deposits.

Site of preliminary colostomy

When a preliminary colostomy is deemed necessary it should be ma
the uppermost part of the pelvic colon and placed in the left iliac
when the growth is within reach of the finger and lower than 10 centim
from the anus. For growths higher in the rectum and in the recto-sig
region a transverse colostomy placed well above the umbilicus on the
side of the abdomen should be made in order to leave the field free
possible restorative resection.

(2) Anaesthesia

Pre-operative measures

One hour before operation Omnopon, $\frac{1}{3}$ grain, and scopolamine, $\frac{1}{150}$ g
are given. Light general anaesthesia, with gas and oxygen, ether, Triler
cyclopropane, is used, together with either a low spinal anaesthetic or gr
small doses of curare. An intravenous drip is started before the patient e
the theatre and, after the patient is anaesthetized, a catheter is passed int
bladder; a Tieman's catheter is used in the male and a self-retaining cath
in the female. It is important to empty the bladder completely by compres
above the pubes. In the female the catheter is removed before the suprap
compression is released and in the male a spigot is placed in the catheter

Drainage of bladder

8. OPERATIVE TREATMENT

(1) Combined excision

This well-established method is the most radical procedure for the treatm
of cancer of the rectum, owing to the frequency of upward spread of
disease along the inferior mesenteric lymphatics. The operation is best p
formed in one stage. There are three recognized methods of combined
cision: the abdomino-perineal excision (Ernest Miles), the perineo-abdomi
excision (Grey Turner and Gabriel) and the synchronous combined excisi
In the first two methods it is necessary to turn the patient between the
dominal and perineal, or perineal and abdominal phases.

Operative methods

In order to describe combined excision anatomically it is proposed to g
a full account of synchronous combined excision, since this operation le
itself to a clear anatomical description, particularly of the perineal dissecti

(2) Synchronous combined excision

In this operation both abdominal and perineal fields are exposed at one a
the same time, there being no need to turn the patient. The patient is plac
in the lithotomy position, utilizing special rests which allow of extension
the thigh away from the abdomen, and the sacrum being raised upon a sma
sand-bag or sacral rest so that the sacro-coccygeal region projects over th
end of the table (Figs. 168 and 169). The scrotum, penis and indwelli
catheter in the male are strapped to one thigh. In the method to be describe
two surgeons work together, one in the perineum and the other, unimpede
in the abdomen, but a single surgeon may operate with a patient in th

Position of patient

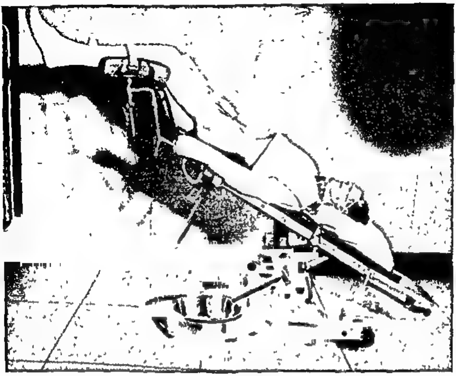


FIG. 168 —Patient in lithotomy-Trendelenburg position, showing special leg supports and sacral rest.

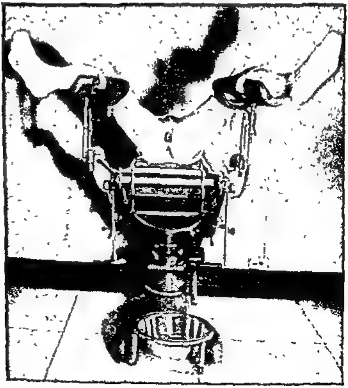


FIG 169 —Perineal view of lithotomy-Trendelenburg position; the coccyx is marked by a dark triangle.

xcision of dvanced rowths

position. The excision of advanced growths is more than ever possible when the patient is in this position, and when two surgeons are working together much time is saved, particularly in cases in which other organs are involved and require resection or dissection (Lloyd-Davies, 1939).

(*a*) *Abdominal approach*

ite of ncision

The abdomen is opened through either a right or a left paramedian incision which extends to the pubis. The whole abdomen is then carefully explored, special attention being paid to the liver and to the large intestine. The primary growth is examined last of all; position, size, degree of infiltration, fixity, relation to other organs and peritoneal involvement are noted, and an examination is made of the lymphatic field.

rial issection

Because local fixity of the growth is often due to perirectal inflammation, before deciding that a growth is inoperable a trial dissection, especially between the growth and the bladder, should be carried out.

The pelvic colon is freed by division of the congenital adhesions on its outer side (Fig. 170) and the left ureter is identified and pushed away from the under aspect of the mesentery of the sigmoid colon. The vascular arrangement in the mesosigmoid is next observed and the point of ligation decided upon in relation to the portion of gut to be utilized for the colostomy. Division of the inferior mesenteric vessels should be as high as possible and is usually either just below or just above the first sigmoid artery. The peritoneum on the right side of the mesosigmoid is now divided from the level of the sacral promontory to the point selected for division of the inferior mesenteric vessels; these vessels are now divided between stout ligatures. The peritoneal incisions on either side of the base of the mesosigmoid are now extended to below the promontory of the sacrum, and the pelvic dissection is commenced. The recto-sigmoid angle is lifted forwards and a pair of blunt-nosed scissors inserted downwards and backwards to the front of the sacrum, and behind the mesorectum. A pre-sacral line of cleavage is thus revealed. The fingers are inserted into this space and the rectum is freed from the sacrum and the lateral walls of the pelvis. This separation is continued down to the tip of the coccyx and any stout bands of fascia are divided between the back of the mesorectum and the front of the sacrum. Sweeping the hand from side to side, the upper portions of the lateral ligaments are made prominent. Peritoneum and extraperitoneal tissue are now divided with blunt-nosed scissors on either side (Fig. 171) and the incisions in the peritoneum are joined in front of the rectum, just anterior to the bottom of the peritoneal pouch. In the male the vesicles are next exposed (Fig. 172) by dissection and the anterior

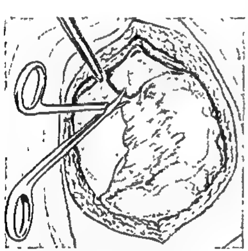


FIG. 170—Dissection of congenital peritoneal adhesions on outer side of pelvic colon.

elvic issection

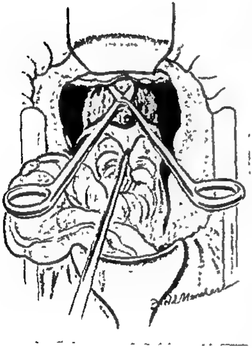


Fig 171.—Division of the peritoneum on the left side of the rectum.

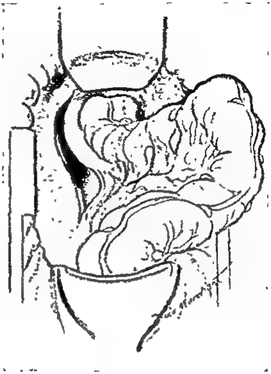


Fig. 172—Exposure of the vesicles by dissection from the abdomen.

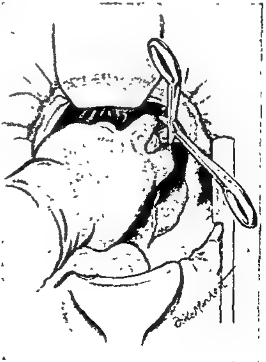


Fig. 173—Division of the upper parts of the lateral ligaments from the abdomen.

Excision of advanced growths

position. The excision of advanced growths is more than ever possible when the patient is in this position, and when two surgeons are working together much time is saved, particularly in cases in which other organs are involved and require resection or dissection (Lloyd-Davies, 1939).

(*a*) *Abdominal approach*

Site of incision

The abdomen is opened through either a right or a left paramedian incision which extends to the pubis. The whole abdomen is then carefully explored, special attention being paid to the liver and to the large intestine. The primary growth is examined last of all; position, size, degree of infiltration, fixity, relation to other organs and peritoneal involvement are noted, and an examination is made of the lymphatic field.

Trial dissection

Because local fixity of the growth is often due to perirectal inflammation, before deciding that a growth is inoperable a trial dissection, especially between the growth and the bladder, should be carried out.

The pelvic colon is freed by division of the congenital adhesions on its outer side (Fig. 170) and the left ureter is identified and pushed away from the under aspect of the mesentery of the sigmoid colon. The vascular arrangement in the mesosigmoid is next observed and the point of ligation decided upon in relation to the portion of gut to be utilized for the colostomy. Division of the inferior mesenteric vessels should be as high as possible and is usually either just below or just above the first sigmoid artery. The peritoneum on the right side of the mesosigmoid is now divided from the level of the sacral promontory to the point selected for division of the inferior mesenteric vessels; these vessels are now divided between stout ligatures. The peritoneal incisions on either side of the base of the mesosigmoid are now extended to below the promontory of the sacrum, and the pelvic dissection is commenced.

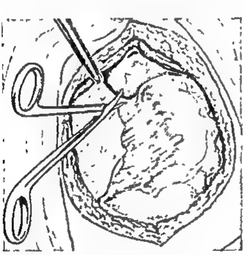


FIG. 170—Dissection of congenital peritoneal adhesions on outer side of pelvic colon.

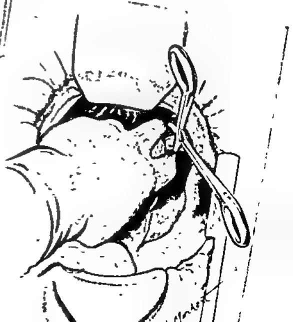
Pelvic dissection

The recto-sigmoid angle is lifted forwards and a pair of blunt-nosed scissors inserted downwards and backwards to the front of the sacrum, and behind the mesorectum. A pre-sacral line of cleavage is thus revealed. The fingers are inserted into this space and the rectum is freed from the sacrum and the lateral walls of the pelvis. This separation is continued down to the tip of the coccyx and any stout bands of fascia are divided between the back of the mesorectum and the front of the sacrum. Sweeping the hand from side to side, the upper portions of the lateral ligaments are made prominent. Peritoneum and extraperitoneal tissue are now divided with blunt-nosed scissors on either side (Fig. 171) and the incisions in the peritoneum are joined in front of the rectum, just anterior to the bottom of the peritoneal pouch. In the male the vesicles are next exposed (Fig. 172) by dissection and the anterior

71.—Division of the peritoneum on the left side of the rectum.

FIG. 172.—Exposure of the vesicles by dissection from the abdomen

73.—Division of the upper parts of the eral ligaments from the abdomen.



Excision of advanced growths

position. The excision of advanced growths is more than ever possible when the patient is in this position, and when two surgeons are working together much time is saved, particularly in cases in which other organs are involved and require resection or dissection (Lloyd-Davies, 1939).

(*a*) *Abdominal approach*

Site of incision

The abdomen is opened through either a right or a left paramedian incision which extends to the pubis. The whole abdomen is then carefully explored, special attention being paid to the liver and to the large intestine. The primary growth is examined last of all; position, size, degree of infiltration, fixity, relation to other organs and peritoneal involvement are noted, and an examination is made of the lymphatic field.

Trial dissection

Because local fixity of the growth is often due to perirectal inflammation, before deciding that a growth is inoperable a trial dissection, especially between the growth and the bladder, should be carried out.

The pelvic colon is freed by division of the congenital adhesions on its outer side (Fig. 170) and the left ureter is identified and pushed away from the under aspect of the mesentery of the sigmoid colon. The vascular arrangement in the mesosigmoid is next observed and the point of ligation decided upon in relation to the portion of gut to be utilized for the colostomy. Division of the inferior mesenteric vessels should be as high as possible and is usually either just below or just above the first sigmoid artery. The peritoneum on the right side of the mesosigmoid is now divided from the level of the sacral promontory to the point selected for division of the inferior mesenteric vessels; these vessels are now divided between stout ligatures The peritoneal incisions on either side of the base of the mesosigmoid are now extended to below the promontory of the sacrum, and the pelvic dissection is commenced. The recto-sigmoid angle is lifted forwards and a pair of blunt-nosed scissors inserted downwards and backwards to the front of the sacrum, and behind the mesorectum. A pre-sacral line of cleavage is thus revealed. The fingers are inserted into this space and the rectum is freed from the sacrum and the lateral walls of the pelvis. This separation is continued down to the tip of the coccyx and any stout bands of fascia are divided between the back of the mesorectum and the front of the sacrum. Sweeping the hand from side to side, the upper portions of the lateral ligaments are made prominent. Peritoneum and extraperitoneal tissue are now divided with blunt-nosed scissors on either side (Fig. 171) and the incisions in the peritoneum are joined in front of the rectum, just anterior to the bottom of the peritoneal pouch. In the male the vesicles are next exposed (Fig. 172) by dissection and the anterior

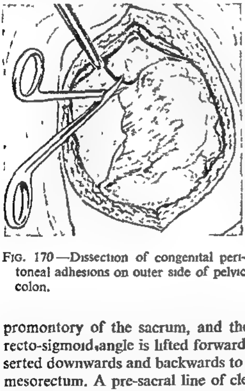
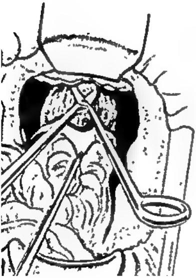


FIG. 170—Dissection of congenital peritoneal adhesions on outer side of pelvic colon.

Pelvic dissection

171.—Division of the peritoneum on the left side of the rectum.



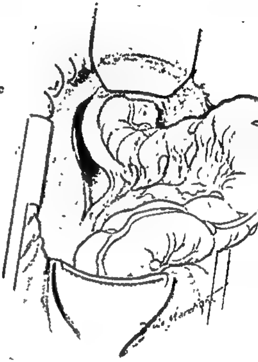


FIG. 172.—Exposure of the vesicles by dissection from the abdomen.

A finger is now inserted in a forward and outward direction on either side between the fascia of Waldeyer and the levator ani muscle. It will be found that the finger can be made to re-enter the ischio-rectal space between the ileococcygeus and pubococcygeus muscles. The coccygeus and ileo-coccygeus muscles have now been isolated with the finger and are divided well out on the lateral wall of the pelvis, together with the overlying ischio-rectal fat and the inferior haemorrhoidal vessels (Fig. 175). The main portion of the fascia of Waldeyer is now seen and is incised just in front of the divided coccyx (Fig. 176), where the middle sacral vessels will require ligation. This incision of the fascia is now extended in a horseshoe-shaped manner on either side to the bony pelvic outlets. The mesorectum is readily separated by the fingers from the front of the sacrum to the level of the promontory and also is freed laterally in a similar manner. The work of the two operators will now have met posteriorly.

FIG. 175—Division of coccygeus and ileococcygeus muscles together with overlying ischio-rectal fat and inferior haemorrhoidal vessels

A St Mark's self-retaining perineal retractor is next inserted and the isolated skin in front of the anus is picked up with a pair of tissue forceps and gentle traction applied. The transverse perineal muscles are now identified on either side as they pass towards the central point of the perineum. The dissection must be kept immediately behind these transverse perineal muscles in order to avoid injury to the urethra. Using a pair of blunt-nosed scissors, the decussating fibres of the external sphincter are divided in the middle line and the whole extent of the transverse perineal muscles is shown. At this stage the white longitudinal fibres of the anterior rectal wall will be seen in the middle line. The broad strap-like fibres of the pubococcygeus muscle on either side will now be seen enveloping the lateral aspects of the rectum. A finger may now be inserted above the superior border of these muscles, separating them from the lateral aspects of the mesorectum whilst they are being divided (Fig. 177).

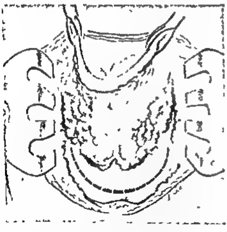


FIG 176—Diagram showing the line of division of fascia of Waldeyer

The lateral aspects of the prostate can now be easily felt and the position of the posterior aspect of the gland determined. The rectum is still held forwards by the undivided inferior edges of the pubococcygeus muscles (puborectalis), and also the longitudinal fibres passing from the anterior rectal wall towards the apex of the prostate, namely the recto-urethralis muscle. The level of the prostatic apex is defined by grasping the sides of the gland with the finger and thumb of the left hand encircling the rectum. A pair of artery forceps is inserted in the middle line towards the prostatic apex, parallel with the posterior aspect of the prostate (Fig. 178). On gently opening these forceps the

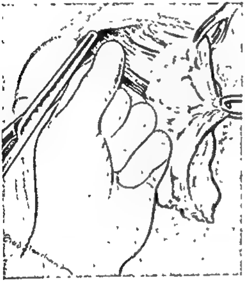


FIG 177.—Division of the right pubococcygeus muscle.

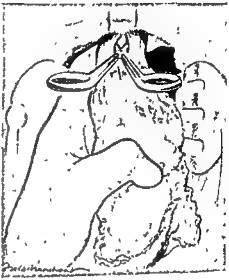


FIG 178.—Exposure of the apex of the prostate

Division of puborectalis muscles

inferior borders of the puborectalis muscles will be identified on either side and separated. These thick muscles are now divided separately. The longitudinal fibres of the recto-urethralis often obscure the prostatic capsule and will require division. Once the plane of the posterior surface of the prostatic capsule is entered the prostate and rectum can readily be separated by blunt dissection with the fingers. Stout visceral layers of pelvic fascia still hold the rectum to the sides of the prostate and will require division; this fascia contains several vessels requiring ligation. The two surgeons will now have met anteriorly. All that remains to be done in order to free the rectum completely is the division of the stout lower portions of the lateral ligaments on either side (Fig. 179).

Delivery of specimen

If the specimen is to be delivered upwards into the abdomen, the anus is enclosed within in a rubber glove. Bleeding points are secured, but the perineal wound is not sutured until the blood-pressure is within reasonable limits. The perineal skin is sutured using everting mattress sutures around a corrugated rubber drain which is inserted through the centre of the wound.

Drainage of wound

In cases in which the peritoneal floor is at a high level and is thin, a rubber bag lightly packed with gauze should be inserted to act as support.

Dissection in the female

In the female the perineal dissection is in the main similar, but when a growth involves the anterior wall of the rectum it is wise to excise the posterior vaginal wall. When this has been done the whole of the perineal wound is

sutured, drainage being provided through the new vaginal orifice; no attempt is made to restore the posterior vaginal wall.

Fig. 179.—Defining the lower portions of the left lateral ligaments by traction of the bowel to the opposite side before its division.

(3) Abdomino-perineal excision

Abdominal dissection

In this operation, the abdominal dissection is exactly the same as that already described, but the dissection is carried down to the level of the fascia of Waldeyer from above.

Colostomy

Colostomy is established in a similar manner but the divided distal bowel is pushed down into the pelvis and the peritoneal pelvic floor reconstructed above it. In order to obtain peritoneum to reconstruct the floor over the bulky bowel, the peritoneum must be mobilized anteriorly from the back of the bladder and also laterally. At the conclusion of the abdominal phase, the patient is turned into the right lateral position and the perineal dissection commenced.

Perineal dissection

Following division of the fascia of Waldeyer, the hand is passed between the mesorectum and the front of the sacrum and the partially dissected specimen is grasped and delivered through the perineum. By holding the divided bowel backwards, the glistening posterior surface of the prostatic capsule will be seen; the anterior dissection is quickly completed, from above downwards, by division of the stout visceral pelvic fascia, the pubococcygei and the decussating fibres of the external sphincter at the central point of the perineum. The peritoneal pelvic floor in these cases is high and the perineal cavity is lightly packed with gauze inside a rubber bag.

(4) Perineo-abdominal excision

This method is favoured by those experienced in perineal dissection of the rectum. The abdomen is first explored through a right paramedian incision and then temporarily closed. The patient is now turned into the left lateral position and the perineal dissection commenced.

Perineal dissection

Dissection is similar to that already described, except that the whole of the lateral ligaments are divided and the peritoneal pouch is opened from below. When the upper border is reached as already described following division of the stout visceral pelvic fascia on either side of the borders of the prostate, the vesicles should be identified. Occasionally these structures may be covered by the stout posterior layer of Denonvilliers's fascia which in such cases requires incision to expose them.

Denonvilliers's fascia

The recto-vesical peritoneal pouch is now opened at this level by division towards the anterior rectal wall. The incision of the peritoneum is carried upwards for several inches on either side of the mesorectum into the pelvis.

The anal canal and anus are now enclosed in a rubber glove, are swabbed with saline solution and pushed upwards into the abdominal cavity. The

anterior free edge of peritoneum is then partially sutured from below with a continuous suture and the needle and catgut are wrapped in a small gauze swab for protection of the needle and later identification from above. The perineal wound is closed with or without a rubber bag.

Closure of perineal wound

The patient is returned to the dorsal position, with the table placed in a moderate Trendelenburg tilt. The abdominal wound is now reopened. The peritoneal incisions on either side of the mesorectum are extended upwards and the growth delivered into the abdomen. The inferior mesenteric pedicle is now ligated.

A muscle-splitting and cutting incision, 3 or 4 inches long, is made in the left iliac fossa. The lateral peritoneal space is closed through the iliac incision and the undivided bowel is delivered through this wound. The peritoneal pelvic floor is reconstructed over an empty pelvis utilizing the suture already used from the perineal wound and the abdomen closed. Finally the incision in the left iliac fossa is closed snugly around the issuing colon, tight enough to allow one finger to pass easily along the colon into the abdominal cavity. A few interrupted sutures carefully placed between the peritoneum or internal oblique muscle and the colon prevent retraction. Transverse incision of the external oblique aponeurosis will prevent constriction at this level. Both wounds are now sealed and dressed and the bowel is divided between clamps.

Closure of abdominal wound

(5) Restorative operations

Certain criteria must be followed when restorative operations are contemplated. Any operation for cancer of the rectum which aims at restoration of continuity must allow of removal of the same upward lymphatic field as would have been obtained by a combined excision. No approach from the perineum or through the sacrum alone can be in any way radical. In addition, the bowel below the lower edge of the growth must be divided at least 2 inches distal to this point, together with the whole mesorectum to this level. In order to retain normal defaecation, not only is preservation of the sphincter muscles necessary, but it is also necessary to preserve the sensitive lining of the anal canal.

Preservation of sphincter muscles

Restorative operations are best carried out in the lithotomy-Trendelenburg position to allow cleansing of the lumen of the bowel below the growth during the operation and also to permit of a change of plan without turning the patient. Careful selection of cases is essential for such operations, and the chances of complete extirpation must not be sacrificed for restoration of continuity unless there are distant metastases.

Position of patient

(6) Intra-pelvic restorative resection

Intra-pelvic restorative resection is the method most generally used. It should be reserved for early rectal growths situated no lower than the level of the pelvic peritoneal pouch, as a rule not within 10 centimetres of the anus, and should be out of reach of the finger from below. Recto-sigmoid carcinomas may also be extirpated by this method and are the most suitable. In order that the proximal colon may be easily anastomosed to the rectal stump deep in the pelvis, the pelvic colon loop and its arterial pattern must be so arranged that a long viable loop of bowel can be placed into the depths of

Recto-sigmoid carcinomas

the pelvis. The build of the patient and the size and depth of the pelvis are also factors to be considered. Palliative restoration of continuity when there are irremovable secondary deposits is most desirable, but the primary growth must be completely removable.

Operative technique

After opening the abdomen, if it is found that preparation of the colon has been inadequate owing to the presence of an obstructing lesion, and especially if the faeces are liquid, a suitably placed preliminary transverse colostomy should be performed as a first stage. *Colostomy*

Following mobilization of the pelvic loop, ligation of the main inferior mesenteric pedicle either above or just below the first sigmoid artery, depending upon the size and extent of the descending branch of the left colic artery, is carried out. The first, and possibly the second, sigmoid arteries are now divided *immediately proximal to their division to form arcades* (Fig. 180). A greater length of viable pelvic colon is thus obtained. The recto-sigmoid and rectum are now mobilized as for combined excision, but this dissection is carried downwards only to a level which will allow of division of the rectum and its mesorectum, 2 inches below the growth. This will ensure an adequate blood supply to the rectal stump. After division of the mesorectum 2 inches below the growth, the bowel is isolated and a right-angle clamp applied at this level. Irrigation of the rectum below this clamp is now thoroughly carried out by an assistant, using hydrarg. perchlor. 1 : 500. This is done with the object of destroying any malignant cells lying free in the lumen which may become implanted at the suture line, and also to cleanse the bowel lumen. The rectum is then completely emptied of irrigation fluid by suction and swabbing. Whilst irrigation is being carried out, the point of division of the pelvic loop is decided upon with regard to its length and vascular supply. It is divided between two Parker-Kerr clamps and sealing caps are applied. The rectum distal to the right-angle clamp is next secured by inserting two holding sutures of black silk, and the bowel divided below the clamp. Haemostasis of the cut edge of the rectal stump is secured and the lumen again swabbed with 1 : 500 solution of hydrag. perchlor. The Parker-Kerr clamp on the proximal bowel is removed, and the lumen is

Division of sigmoid arteries

Irrigation of the rectum

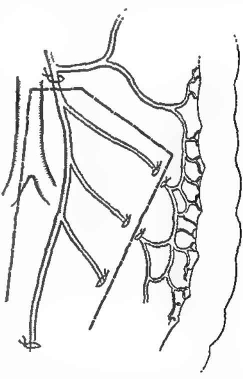


FIG. 180—Illustrating the method of division of sigmoid arteries to obtain greatest length of viable bowel.

cleansed and enlarged by incising the antimesenteric border. A careful end-to-end anastomosis without any tension is now performed in two layers.

When the anastomosis lies low in the pelvis, the peritoneal floor is finally closed over it, and the divided peritoneum on either side of the pelvis is sutured to the edge of the pelvic colon.

Drainage

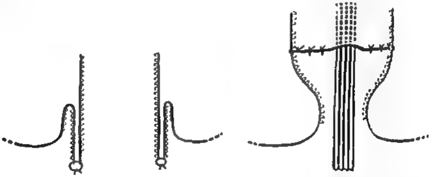
The site of anastomosis is drained by two corrugated rubber drains one in front and the other behind the suture line. If the anastomosis has been at all difficult or if preparation of the bowel has not been entirely satisfactory, it is usually wiser to perform a temporary transverse colostomy through a separate stab incision at the end of the operation before the abdomen is closed. The colostomy is opened after the abdominal wounds have been sealed and dressings applied. A rubber tube ($\frac{1}{2}$-inch bore) is inserted into the rectum through the anus to prevent distension by flatus within the rectum; or alternatively a flatus tube may be passed just within the rectum two or three times daily.

(7) Abdomino-anal resection

This method is permissible only for very small early tumours situated just within reach of the finger and lying below the peritoneal pouch. It is rarely used and it requires a much longer loop of pelvic colon than would suffice for an intra-pelvic anastomosis. The main vascular pedicle is secured in exactly the same way as in the previous operation and the lowest point of viability marked with a black ligature.

Abdominal dissection

The abdominal dissection is continued down to the pelvic floor as described in the abdominal approach of abdomino-perineal incision. When the bowel has been freed from above, an assistant dilates the anus and then inserts a small swab into the rectum to exclude the growth from the distal segment. The rectum is now swabbed with 1 : 500 hydrarg. perchlor. By gentle pressure within the pelvis from above and gentle



(a) (b)

FIG. 181.—Showing method of anastomosis and drainage of pre-sacral space.

Prolapse of rectal wall

traction from below, a small cuff of rectal wall is prolapsed through the anus. This prolapsed cuff is held in four tissue forceps and incised through all its [illegible]

[illegible] of viability is seen. The pelvic colon is divided at this point and cleansed [illegible]

Drainage

layers (as for recto-sigmoidectomy) (Fig. 181). Drainage of the [illegible]

space is carried out by inserting a rubber drainage tube through the posterior part of the suture line; the anastomosis being then returned through the anus. The reconstitution of the peritoneum of the pelvic floor is now carried out by the abdominal surgeon and the abdomen closed. The indications for transverse colostomy are similar to those described for intra-pelvic anastomosis.

(8) Perineal excision (Lockhart-Mummery)

This operation is carried out either in the lithotomy or left lateral position. It is a palliative procedure and is only used for growths in the lower third of the rectum in patients whose general condition will not warrant an extensive radical combined excision. A preliminary colostomy is performed 14 days before excision and the lower segment is washed through daily. Details of perineal dissection have already been described fully. The peritoneal pouch is sought on the anterior rectal wall and opened, and the rectum mobilized by division of the lateral ligaments from below. The superior haemorrhoidal vessels are divided as high as possible and ligated. The semi-lunar opening in the peritoneal pouch is now closed by continuous sutures which commence at each corner and terminate in the middle line. The bowel is divided between two small crushing clamps, 1½ inches below the closed peritoneal floor, and the proximal end of the bowel closed and invaginated by means of a Mikulicz stitch and if possible by a further purse-string suture. In order to diminish the chances of the troublesome mucous leak (perineal fistula), any redundant peritoneum below the sutured peritoneal floor should be stitched over the divided and closed bowel. The pelvic cavity is lightly packed with gauze within a rubber bag and the perineal skin sutured.

Preliminary colostomy

Perineal fistula

(9) Hartmann's operation

This operation (anterior resection with colostomy) may be performed for recto-sigmoid or high rectal growths for which anterior restorative resection has been contemplated but found impossible after division of the bowel because of insufficient length of proximal colon, or when the patient will not stand an additional perineal operation (combined excision). The distal stump of bowel is closed, invaginated and the peritoneal floor reconstituted. The proximal end of the bowel is brought out as a colostomy through an incision in the left iliac fossa.

9. POST-OPERATIVE TREATMENT

The patient is nursed lying flat with the foot of the bed placed on 6-inch or 8-inch blocks for the first twelve hours. During the operation one pint of blood is given and further transfusion may be required during the post-operative period. Intravenous fluids are continued, giving 3–4 litres in 24 hours of a solution consisting of one part of normal saline in four parts of 5 per cent dextrose in water. When a restorative resection has been performed, penicillin and Sulphamethazine are given for the first three or four post-operative days. Fluids by mouth are withheld and intravenous fluids continued until normal peristalsis is heard on auscultation or flatus is passed. Slight abdominal distension or nausea will require prolonged continuation of intravenous therapy and gastric suction must be instituted early in such cases. When normal bowel

Intravenous fluids

Penicillin and Sulphamethazine

sounds are audible, a colostomy, when present, is encouraged to act, first by the insertion of a few glycerin suppositories or by the injection of a few ounces of warm olive oil through a No. 12 rubber catheter. If abdominal drains have been used, these are gradually shortened from the third day onwards, but must not be totally removed for at least a week. A drainage tube in the perineal cavity is removed in 48 hours, and when packing inside a rubber bag has been used, about half the packing is removed on the second day and the remainder, together with the bag, on the third day. Hereafter the perineal wound is irrigated twice daily. Patients with perineal wounds should not be nursed on their backs for any long period but should be frequently turned from hip to hip. The pre-sacral drain used in abdomino-anal resection is removed on the fourth day. In order to prevent retention of exudate in the pre-sacral space in such cases, inspection must be carried out and irrigation may be necessary through the suture line. The indwelling urethral catheter is attached to an antiseptic seal as described by Dukes (1928), and the bladder emptied 4-hourly. This catheter is removed about the fourth or fifth day, or before then if the patient passes urine along the side of it. In women, regular catheterization is required for the first few days. As a rule the patient is encouraged to get out of bed for a short period on the fifth day. When a colostomy is present this is trimmed on the seventh day to leave about one inch of bowel projecting from the abdominal skin.

Abdominal drains

Removal of packing

Catheterization

Trimming of colostomy

10. RESULTS OF TREATMENT

Synchronous combined excision series

Out of a total of 361 cases of carcinoma of the rectum, 317 cases (87·8 per cent) were resected by the synchronous combined excision method, and in many instances other involved organs were removed at the same time. There were 26 deaths (mortality 7·2 per cent). The remaining cases, 44 in number, were considered to be inoperable on account of gross involvement of the liver or peritoneum by metastases, or because of extensive pelvic spread. These latter cases were only abandoned after determined trial dissection.

TABLE

FIVE-YEAR SURVIVAL RATE (OPERATION DEATHS EXCLUDED) OF COMBINED EXCISION OPERATIONS, 1928–41 INCLUSIVE

Dukes's classification	No. of cases	Percentage	Untraced, regarded as dead	Died within 5 years, from any cause	Alive at 5 years	Per cent 5-year survivors
A	46	12 6	0	7	39	84 8
B	122	33 3	1	43	78	63 9
C	198	54 1	3	129	66	33 3
TOTAL	366	100	4	179	183	50

Resectability rate

The resectability rate in the last 100 cases was 98 per cent; only 2 cases were regarded as non-resectable and for these palliative colostomy was performed.

From the figures given in the Table above it will be seen that a combined excision gives those patients who have survived the operation a 50 per cent chance of a five-year cure.

Restorative operations are at present in the experimental stage. Even in selected cases there appears to be a much greater risk of local recurrence than after combined excision operations. In a series of 65 cases recently investigated (Lloyd-Davies, 1948) 14 patients developed local recurrences in the region of the suture line, and two developed second primary carcinomas in the remaining rectum.

11. TREATMENT OF INOPERABLE CASES

(1) Palliative colostomy

This operation is performed through a left iliac muscle-splitting incision. The upper part of the pelvic colon is withdrawn through the wound and in patients with a short mesentery the congenital peritoneal folds on the outer side of the mesocolon may require division. The lateral space is closed as described in the combined excision operation and a glass rod is passed through an avascular portion of the mesentery. The peritoneum is now closed round the emerging loop of colon sufficiently tightly just to allow one finger to be passed alongside the bowel into the peritoneal cavity. A few tacking sutures are placed between the peritoneal edge on the medial side and the two limbs of bowel and mesentery to prevent prolapse of small intestine.

The muscle layers are then closed—lateral incisions being made in the external oblique aponeurosis opposite the emerging colon. The skin is closed with vertical mattress sutures, but before completing this an ellipse of skin is excised from both sides of the wound opposite the bowel to prevent skin stenosis. Large appendices epiploicae on the surface of the bowel are ligated and excised provided they contain no diverticula. The skin is sealed with Whitehead's varnish, dressings and the over dressings and rod are held in position and covered with Elastoplast strapping which is made to fit snugly round the protruding colon

Prevention of stenosis

Appendices epiploicae

Superficial packs or towels are now placed round the bowel, which is then opened with a short transverse incision and a longer longitudinal incision. Bleeding points are ligated. A cautery should not be used since the Whitehead's varnish contains ether. The opened colostomy is dressed with Vaseline gauze.

The advantages of immediate opening are now well known: post-operative pain from gas distension rarely occurs and there appears to be no risk of wound sepsis.

(2) Curettage and diathermy

This treatment is suitable for stenosing growths in the lower third or ampulla of the rectum. The growth is thoroughly curetted, all raised portions being removed and the surface is fulgurized with the diathermy. This procedure widens the lumen of the bowel and reduces the discharge. In a few suitable cases a colostomy may thus be avoided for the few remaining months of the patient's life.

(3) Intrathecal alcohol injections

Position of patient

These injections are of value in those cases with severe and persistent perineal pain. Between 0·5 and 0·7 cubic centimetre of absolute alcohol is very slowly injected into the theca with the patient in the knee-chest position and the spine at an angle of 45 degrees. Pressure upon the jugular veins will be required to ascertain when the needle is in the theca, and the patient is kept in the above position for 20 minutes after the injection.

Urinary retention is apt to be a troublesome complication especially if large doses are used.

(4) Radiotherapy

This method of treatment can, on occasion, be helpful in reducing pelvic pain and rectal discharge. Ordinary deep x-ray therapy is of no value; a penetrating beam is essential. Unfortunately the treatment itself is very debilitating, and of the 12·2 per cent regarded as inoperable practically none is fit enough to undergo this treatment.

REFERENCES

Broders, A. C. (1925) *Minn. med.*, 8, 726
Dukes, C. E. (1928) *Proc. R. Soc. Med.*, 22, 1132
Lloyd-Davies, O. V. (1939). *Lancet*, 2, 74.
— (1948). *Proc. R. Soc. Med.*, 41, 822

[References to other titles are given under Rectum—Carcinoma of, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol. 10, p. 502.]

RECTUM—HAEMORRHOIDS

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1. DEFINITION

291.] "Haemorrhoids" is the name given to a disease characterized by distension of veins and their coverings in the rectum, the anal canal, and at the anus.

2. SURGICAL ANATOMY

(1) The three primary piles

Situation

The conglomerate mass of haemorrhoids can be divided into three separate parts, whether seen externally when prolapsed, or seen internally through a proctoscope (Fig. 182). These three distinct piles are situated one on the

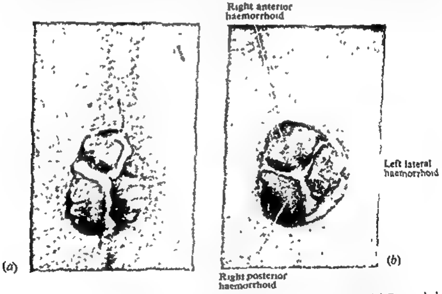


FIG. 182.—Photograph to show the three primary haemorrhoids. (*a*) Distended external haemorrhoids; (*b*) prolapsed internal haemorrhoids.

left side and two on the right side of the anal canal. Their recognition is fundamental to the understanding of the subject.

Secondary piles

They were named by Miles (1919) as the left lateral pile, the right anterior pile and the right posterior pile. The left lateral pile has three smaller secondary piles; the right posterior has two secondary piles; the right anterior has no secondary pile.

No more need be said about secondary piles, for they are not constant and as they have no pedicle can be included for treatment with the primary piles.

Very occasionally, when large, they appear as isolated swellings at the midline anteriorly and posteriorly and call for separate ligation and removal, or injection.

(2) The three parts of the pile

Each pile consists of three discernible parts (Figs. 183 and 184).

The pedicle is situated in the rectum. It is covered by characteristic pale pink rectal mucosa. The returning veins can be seen through the transparent

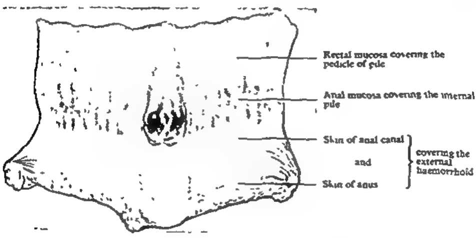


FIG 183.—Rectum and anal canal opened from behind, showing the coverings of the three parts of the anterior pile.

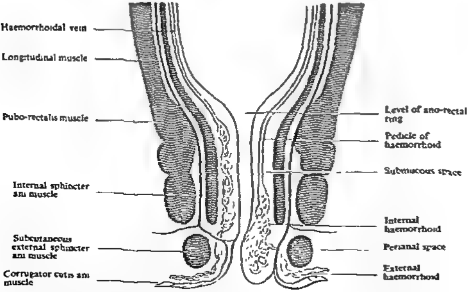


FIG. 184.—Diagram to show the three parts of a pile and prolapse of a pile (right). Note the piles lie in the submucous and the perianal spaces. The diagram also shows the termination of the longitudinal muscle and corrugator muscle and the subcutaneous external sphincter ani.

mucosa and pulsations of an *artery* can sometimes be felt in the pedicle. The arteries are usually small and not visible.

The internal pile commences above at the *ano-rectal* ring and ends at the muco-cutaneous line [illegible] lining. [illegible] enveloping three layers of sphincter ani muscles.

The external pile extends from the muco-cutaneous line in the anal canal to its well-defined border at *the anus, so it lies* partly inside and partly outside the anal canal and is weakly *supported by* but one sphincter muscle, the subcutaneous external sphincter ani; the external pile *is usually the first* to prolapse.

Skin covering The external pile lies in the perianal space and is covered by two *types* of skin: the smooth shining glandless skin in the anal canal and the ordinary

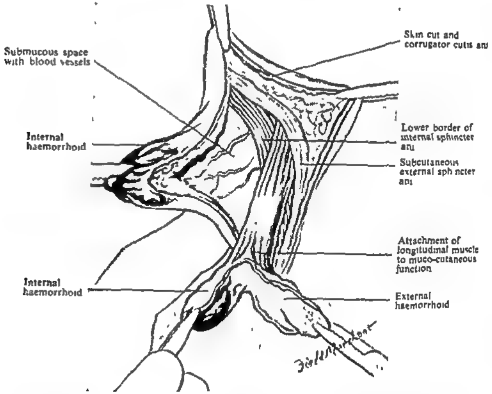


FIG 185.—Dissection to show an attachment of the longitudinal muscle to the skin of anal canal at the junction of internal haemorrhoid and external haemorrhoid.

glandular hair-containing skin of the anus. It is very sensitive to stimuli of pain and touch.

The pedicle and the internal pile lie in the submucous space, an area insensitive to painful stimuli of burning and pricking but sensitive to distension as experienced in the injection treatment.

The submucous space and the perianal space occupied by the pile are separated by the intermuscular septum of the longitudinal muscle. This *Fibromuscular septum* fibromuscular septum is all-important in keeping the pile in its place in the anal canal, for it is attached strategically to the anal canal lining between the internal and the external pile (Figs. 184 and 185). When this muscle is well

developed and is acting efficiently a groove or depression can be recognized on the surface of the pile at the muco-cutaneous junction between the internal and the external pile (Fig. 186). When the muscle attachment is absent, stretched, weakened or poorly developed, the depression or groove is absent (Fig. 187). This is characteristic of the third-degree pile. *Characteristic groove*

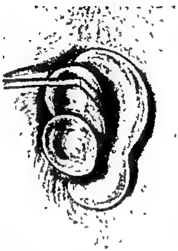


FIG. 186.—A prolapsed thrombosed intero-external left lateral haemorrhoid. The retractor shows the groove between internal haemorrhoid and external haemorrhoid caused by the intact intermuscular septum of the longitudinal muscle

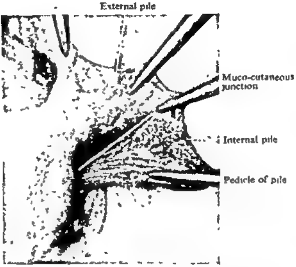


FIG. 187.—A prolapsed third-degree anterior pile. Mark the absence of the groove due to attachment of the longitudinal muscle. The site is marked by straight line.

(3) Muscles of the anal canal in relation to haemorrhoids

In the causation and symptoms of haemorrhoids all sphincter muscles of the anal canal and rectum play a part, but only three of these muscles are concerned with the operation for removal of haemorrhoids.

(a) *The subcutaneous external sphincter ani muscle*

This is the ring-shaped muscle surrounding the lower end of the anal canal and orifice (Fig. 188). Its outline can be seen under the skin of the anus. On its inner and superficial aspects lies the external haemorrhoidal plexus covered by skin and the corrugator cutis ani muscle. Its upper border is an easily definable landmark which can be felt at the intermuscular septum.

(b) *The intermuscular septum of the longitudinal muscle*

The longitudinal muscle of the bowel, after surrounding the rectum and anal canal, terminates by gaining attachment to the lining of the anal canal, at the muco-cutaneous line. This termination is named the anal intermuscular septum, and lies between the internal sphincter muscle and the subcutaneous external sphincter ani muscle. It then spreads downwards and radiates *Anal intermuscular septum*

laterally under the skin of the anal canal and anus as the corrugator cutis ani muscle (Fig. 184).

(c) *The corrugator cutis ani muscle*

This muscle is recognized by its close attachment to the skin of the anal canal and anus as it loses itself over the ischio-rectal fossa.

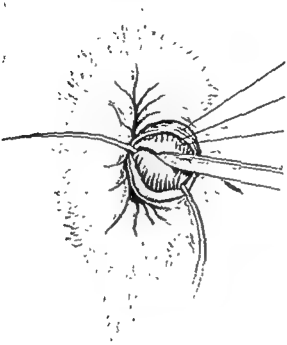


FIG. 188.—Dissection to show the subcutaneous external sphincter ani and its superficial relations. The muscle is here picked up by a needle passed *under its upper border.*

(4) Submucous and perianal spaces

(a) *The submucous space*

This space contains the vessels of the pedicle and the internal haemorrhoid. The space is directly continuous above with the submucous space of the bowel; below it is separated from the perianal space by the intermuscular septum of the longitudinal muscle.

(b) *The perianal space*

Contents This space surrounds the anus (Fig. 184). It is subcutaneous and contains *the external haemorrhoidal plexus lying on the subcutaneous sphincter* amidst perianal fat. The intermuscular septum of the longitudinal muscle and the transverse septum which crosses the ischio-rectal fossa, together form the upper boundary of the perianal space, separating it from the submucous and ischio-rectal spaces above. Superficially the space is covered by skin and corrugator cutis ani muscle, both of which must be cut to gain entrance into the space.

The submucous and perianal spaces are both opened in the operation for haemorrhoids, the perianal by the skin cut and the submucous by the strangulating ligature. It is into the submucous space that sclerosing solutions are injected and are then free to spread.

The painful complications of external haemorrhoids, such as perianal haematoma and thrombosis, occur in the perianal space. It is into this space

that anaesthetic solutions are injected to give relief from pain in fissure-in-ano or to produce insensitiveness in operations and in pruritus ani. If infection follows these measures it is limited to the space where it is more easily dealt with by surgery than are the ischio-rectal space infections.

(5) Blood-vessels

(a) *Arterial supply*

The chief arterial supply (Fig. 189) to the haemorrhoids is from the superior haemorrhoidal artery. It is a direct continuation of the inferior mesenteric artery. *Superior haemorrhoidal artery*

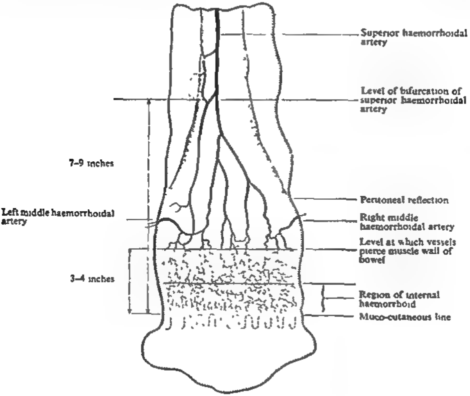


FIG. 189.—Diagrammatic representation of arterial supply to haemorrhoids. The rectum is viewed from behind.

The superior haemorrhoidal artery descends into the pelvis in the root of the mesocolon and on the posterior surface of the rectum opposite the third piece of the sacrum or 7–9 inches above the muco-cutaneous junction; it divides into two main branches, left and right. *Distribution of branches*

Passing down on the postero-lateral aspects of the rectum these two main branches divide half-way down the rectum or 4 inches above the anus into smaller branches which pierce the muscular coats and then proceed to each haemorrhoid as numerous branches in the submucous space of the rectum. The branches are distributed through the pile pedicle to the three primary piles. They are small and inconspicuous but sometimes a large branch can be palpated in the pedicle of the pile.

Arterial supply to the external haemorrhoids from the inferior haemorrhoidal arteries varies a great deal. In some cases many bleeding arteries will need ligation in the incision whereas in other cases only one vessel is seen, and in most instances there are no bleeding arteries.

(b) Venous return

The venous return from the internal and external haemorrhoids can be seen through the proctoscope as single veins under the transparent mucosa of the rectum. Their course is irregularly upwards in the submucosa from each of the primary piles and they disappear abruptly after a course of 3 or 4 inches by piercing the rectal muscle wall to gain the mesorectum where they accompany the superior haemorrhoidal artery and finally join the portal system through the inferior mesenteric vein which joins the splenic vein. They are said to be devoid of valves and so the terminal veins in the internal and external haemorrhoids bear the brunt of increased intra-abdominal pressure.

Course

Absence of valves

The external haemorrhoidal plexus is predominantly grouped into three segments corresponding to the three internal haemorrhoids.

3. AETIOLOGY

Haemorrhoids are developmental in origin. They depend on the number, condition and size of the blood-vessels in the submucosa of the rectum, anal canal and anus; on the nature of the coverings, the mucosa and skin; and on the tone and arrangement of the supporting anal musculature. These all vary in different individuals. These basic conditions begin to operate detrimentally in adult life when life's stress and strain are manifest and tone diminishes.

Other contributing factors are trivial compared with this congenital arrangement of blood-vessels, muscular support and, also, man's erect posture. Portal obstruction and increased intra-abdominal pressure, as in pregnancy and in straining in urinary obstruction, precipitate the symptoms of piles. Straining at stool in constipation and diarrhoea will aggravate the prolapse or bleeding, and patients learn to alleviate their symptoms with aperients and ointments.

Straining

The determining mechanical factors in haemorrhoids are not unlike those in varicose veins of the legs. When the anal canal is long and closed, the sphincter muscles adequately support the haemorrhoidal veins, like the deep veins of the legs. When the anal muscles relax as in defaecation the vessels in the submucosa have no support, not unlike the subcutaneous veins of the leg.

Determining mechanical factors

4. SYMPTOMS

(1) Bleeding

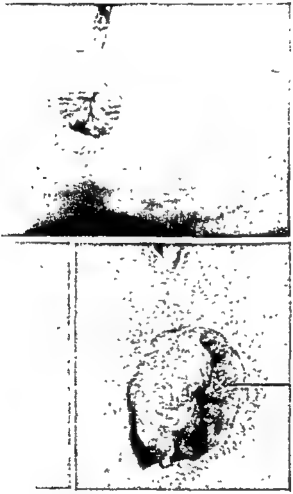
Bright red blood small in amount occurring at defaecation may be the first arresting symptom. It is seen by the patient to smear the stool, or is seen on the paper. It may spurt on the pan or may stain the clothing. Sometimes it is profuse enough to fill the rectum and pour from the anus, producing a grave anaemia demanding blood transfusion.

Anaemia

It is caused by blood oozing or spurting through the delicate anal mucosa which covers the internal haemorrhoid when the haemorrhoid becomes

Causes

t in the knee-chest position er the left lateral posi-
There may be no evidence of the existing piles at the
, tags of skin in the quadrants of the three primary *Skin tags*
ce of large internal haemorrhoids. These piles will



howing distension, eversion and prolapse on straining,
te the skin of anal canal begins to show.

: on bearing down (Fig. 191). The piles may,
piles and then the skin of the anal canal or
, at the anus according to the amount of

e or absence of ...ve" between the
ls is noted. Thi- haemorrhoid *Classification*
gree, but ... most in this

become aperient addicts. Not till the rectal condition is cured and fear allayed can natural daily defaecation be established and the aperient habit abandoned.

(6) Effect of piles on life and character

Lowering of efficiency

Not only do haemorrhoids produce deep depression and irritability but they cause tiredness and fatigue. Joy and efficiency in work are lowered and many patients are hard to live and to work with. The patient's mind becomes preoccupied with his piles, his aperients and his daily motion, which he anticipates with fear. It often ends in a feeling of frustration carried throughout the day and communicated to others. Indeed, the daily routine of life may be dependent on and determined by the bowel action. It is no wonder that after the radical cure of haemorrhoids, with restoration of bowel function and bodily and mental well-being, such remarks as "I am a new man with a new outlook," or "My wife says she has a new husband," are made by a grateful patient, for haemorrhoids can bring out all the defects and weaknesses in human character and human relationships.

5. DIAGNOSIS

This is made on the history of the patient's condition and is confirmed by subsequent examination of the part.

As the patient lacks the words to describe his symptoms, the necessary words are given by leading questions in a helpful manner, and at St. Mark's Hospital

ST. MARK'S HOSPITAL

Rectal Case Sheet

Complaint on Admission . . . .

Duration of Symptoms . . . . . Continuous or Intermittent . . . . . .

Bleeding . . . . . . with / between } stools . . . .

Pain . . . . continuous . . . .

during and after defaecation . . . .

Prolapse . . . after motion . . . . . . during day . . . .

reduces spontaneously . . requires replacement . . .

Swelling. . . Discharge . . . .

Diarrhoea . . . . duration . . number of stools . . . . tenesmus . . . . .

Constipation . . Alternate diarrhoea and constipation . . . .

Irritation. by day . . . . by night. . . . .

Loss of Weight. . . . . Other Complaints. . . . .

FIG 190.—Planned history sheet.

Planned history sheet

a plan embodied in a history sheet is used (Fig. 190). This gives the clue to the presence of haemorrhoids and their degree. It also raises the suspicion of accompanying lesions, for patients are apt to call *all* diseases of the rectum "piles".

Clinical examination

(a) *Inspection*

Inspection is carried out in the knee-chest position or the left lateral position, using a good light. There may be no evidence of the existing piles at the anus. On the other hand, tags of skin in the quadrants of the three primary piles indicate the presence of large internal haemorrhoids. These piles will *Skin tags*

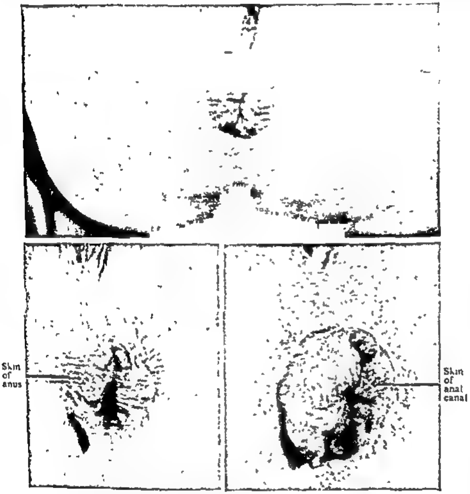


FIG. 191 —External haemorrhoids showing distension, eversion and prolapse on straining, as in defaecation Note the skin of anal canal begins to show.

distend with blood and prolapse on bearing down (Fig. 191). The piles may, however, present as prolapsed piles and then the skin of the anal canal or the mucosa of the pile appears at the anus according to the amount of prolapse (Fig. 182).

If a pile is prolapsed the presence or absence of the "groove" between the internal and external haemorrhoids is noted This classifies the haemorrhoid into the second or the third degree, but the history helps most in this all-important classification *Classification*

The presence of thrombosis, *strangulation* or infection will be noted and will be observed whether it is possible to replace the prolapsed pil...
Accompany...

... can be inspected by everting the anus gently wit the fingers.

(b) Palpation

The examining finger initiates the desire to defaecate and so the patien sometimes resists, not so much from the discomfort felt as from the fear tha the bowels will open. He should be warned beforehand and assured that thi will not happen and thus his co-operation can be gained.

Haemorrhoids of the first and early second degree cannot be palpated. As the examining finger is lightly rotated in the anal canal, third-degree haemorrhoids or fibrous anal polypi may be felt at the ano-rectal ring. The righ anterior pile feels like a projecting longitudinal fold of mucosa, whereas the other two piles are felt with their secondary piles as *soft masses of lining* membrane on each side of the anal canal.

Exclusion of other lesions

To exclude accompanying lesions the finger should then palpate the rectum and, more important, the recto-sigmoid by pressing upwards on the perineum, thus the bowel can be examined for 9 centimetres and the narrower colon felt. So in turn the anal canal, rectum, and recto-sigmoid are each palpated and attention given to palpating the pelvic organs through the rectal wall.

(c) Proctoscopy

The 3-inch tubular St. Mark's pattern proctoscope (Fig. 192), warmed and well lubricated, is inserted full length through the anal canal into the rectum Time is given for the rectum to distend, then the stretched mucosa with its underlying blood-vessels and the faecal contents is examined. The proctoscope is then withdrawn to the ano-rectal ring which appears as a rim of mucosa at the end of the proctoscope. Further withdrawal will bring it to the pile-bearing area, lying just below the ano-rectal ring, in the upper part of the anal canal. The haemorrhoids, if present, will now bulge or prolapse as irregular masses of mucosa into the lumen of the end of the proctoscope. A little upward pressure with the proctoscope will make the piles more manifest. Their size and arrangement, and the vascularity of the mucosal covering will be noted. Finally the amount of prolapse can be tested if the proctoscope is further withdrawn to the

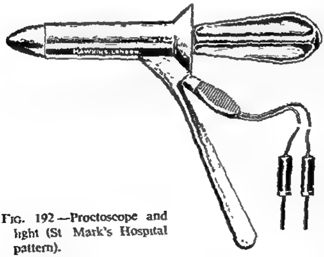


FIG. 192.—Proctoscope and light (St. Mark's Hospital pattern).

Amount of prolapse

skin-lined area and the patient is instructed to strain down. The prolapsing piles will follow and prolapse of rectum will be recognized if present.

The decision to inject or operate is made on the history—confirmed by the appearance, size and fixity of the haemorrhoids on palpation and inspection.

(*d*) *Sigmoidoscopy*

This is carried out as a routine procedure to exclude malignant disease or adenoma of the colon which may be coexistent at a higher level and give rise to bleeding or even to prolapse.

6. PRE-OPERATIVE TREATMENT

On the evening but one before the operation an aperient is given to ensure emptying of the colon. It should not cause purgation. The patient who takes aperients should take double his accustomed dose. For those who do not take aperients ½ drachm of Cascara Evacuant is usually sufficient. Light non-residue diet is given on the day before operation. *Aperient* *Diet*

The evening before the operation the anus is shaved and a hot bath is given; the part is well washed with soap and water. The morning of the operation the patient should empty the rectum and colon by defaecation. To complete this a wash-out of tap water is given with funnel and tube 2–3 hours before operation until the return is clear. *Wash-out*

7. OPERATIVE TREATMENT

(1) General principles

Ligation and excision is the routine operation practised at St. Mark's Hospital, to the exclusion of all others. The aim of the operation is twofold: to *Aim*

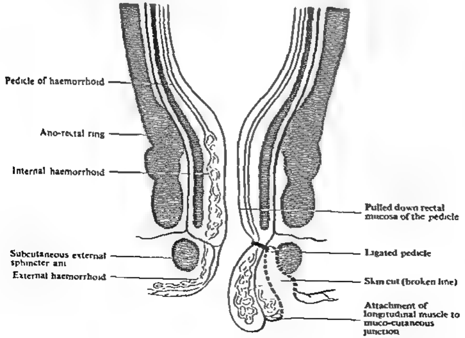


FIG. 193.—Diagram to show plan of operation for haemorrhoids The ligature encircles the rectal mucosa, vascular pedicle of the haemorrhoid and the exposed longitudinal muscle.

remove the three parts of the three haemorrhoids and to leave adequate intervening intact skin and mucosal bridges from which regeneration of lining epithelium takes place to cover the raw areas.

Plan

The plan of the operation is to dissect up the external haemorrhoid, thus putting the internal haemorrhoid on its pedicle so that a strangulating ligature can be placed round the pedicle and include the longitudinal muscle which the dissection exposes (Fig. 193).

(2) Anaesthetic

There are many choices nowadays. The guiding principles are to confine the anaesthesia to the operation area (S 4 and 5) and to prevent apprehension The first objective can be obtained by low spinal (sacro-spinal) anaesthesia or by local *anaesthesia, the second by premedication with Omnopon up to doses* of $\frac{1}{3}$ grain, scopolamine, $\frac{1}{150}$ grain, and Nembutal, 3 grains, for a middle-aged healthy adult. As an alternative Pentothal Sodium with inhalation anaesthesia can be used, as giving the patient the least upset and circumventing complications. Finality of agreement on the best anaesthetic has not yet been reached, but low spinal anaesthesia gives the best exposure from the surgeon's point of view and lessens after-pain. For this 0 4 cubic centimetre of heavy (1 : 200) Nupercaine is given in the sitting position.

(3) *Position*

The patient is placed in the lithotomy position which stretches and exposes the part. The surgeon and his two assistants are seated before the field of operation The operation area is prepared with soft soap, followed by an antiseptic lotion. Towels are fixed round the field of operation

FIG 194 —The "triangle of exposure" of haemorrhoids for operative removal. Artery forceps are applied to the pedicles of the prolapsed haemorrhoids. All haemorrhoids are so exposed and lie below the triangle thus formed.

Instruments

Instruments used are toothed dissecting forceps, 6-inch blunt-ended scissors, 1 dozen 5-inch artery forceps, three 12-inch lengths of No. 16 hollow woven silk, and catgut to tie bleeding points. These are placed on a towel-draped instrument table between the surgeon and field of operation.

(4) Exposure of the haemorrhoids

The first step is to expose or prolapse the three primary piles and apply an artery forceps to each pedicle (Fig. 194). These are the "pedicle-holding forceps" and serve for traction by the assistants throughout the operation. The piles are

prolapsed by everting the haemorrhoids in turn, beginning at the most prolapsed. *Prolapse of piles*

The internal haemorrhoid, exposed by pulling on the external haemorrhoid, is grasped with the dissecting forceps above the attachment of the longitudinal muscle and gently pulled downwards and outwards in its radial position. Traction on the external haemorrhoid alone will not expose the pedicle. When the pedicle, which appears as a fold of rectal mucosa and is recognized by its pink colour, comes into view it is grasped firmly with an artery forceps parallel with the pedicle. The forceps is given to an assistant to retract. In this way a pedicle forceps is applied to the pedicle of all three piles in turn, which are then retracted and held by assistants. The left lateral pile is held by the assistant on the right side and the right anterior and right posterior piles by the assistant on the left side of the operator in their radial position. There is thus formed a triangle—"the triangle of complete exposure". The sides of the triangle are formed by mucosa at the ano-rectal ring and at the corners are the three pedicles. This exposure assures the surgeon that all three piles are exposed as all the haemorrhoids lie below this line. Further swabbing of the exposed area with antiseptic lotion can now be done. *Pedicle forceps* *"Triangle of complete exposure"*

(5) Dissection of the haemorrhoids

This is done in turn, beginning at the left lateral, then the right anterior and finally the right posterior pile. To facilitate this dissection an artery forceps is placed on the skin of the anus covering the external haemorrhoid to be removed; a big or smaller "bite" being taken according to the amount of redundant skin. This traction forceps is called "the skin-holding forceps". *Skin-holding forceps*

The pedicle forceps and the skin-holding forceps are now held in the palm of the left hand of the operator while the index finger of the same hand is placed in the anal canal supporting the haemorrhoid. So the skin is put on tension and the pile steadied while the cut and dissection are made. The blades of the scissors are placed one at the mucocutaneous junction and the other at the outer border of the external haemorrhoidal plexus (Fig. 195). A V-shaped cut is made, a limb on either side of the skin-holding forceps. It is made through the skin and the underlying *The skin cut*

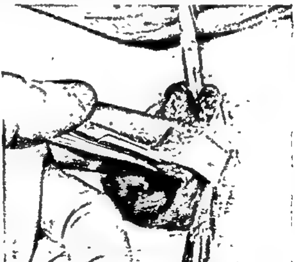


FIG. 195.—Dissection of the left lateral haemorrhoid to expose the longitudinal muscle and to put the haemorrhoid on its pedicle ready for ligation.

corrugator cutis ani muscle, the radial fibres of which can be identified by their adherence to the skin.

This opens the perianal space at the outer border of the external haemorrhoid and reveals the circular muscle fibres of the subcutaneous external sphincter ani muscle. The external haemorrhoid is dissected with the scissors, and lifted off the subcutaneous external sphincter to its inner border. Here the longitudinal fibres of the intermuscular septum of the longitudinal muscle of the rectum are seen, on the stretch, attached to the pile (Fig. 196). The dissection is neatly completed and the two forceps are handed to the assistant.

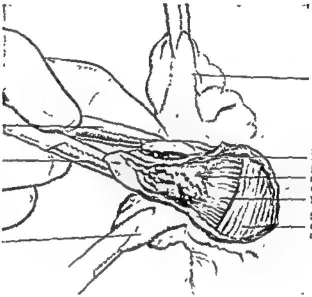


FIG. 196.—The skin cut is made with scissors from the muco-cutaneous line to the outer border of the external haemorrhoid plexus Note traction on the skin-holding forceps and the pile being steadied by the index finger in the anal canal

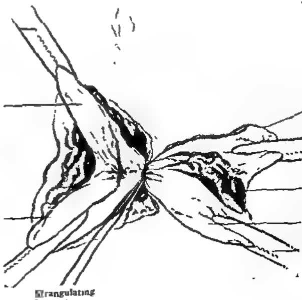


FIG 197.—Left lateral haemorrhoid dissected on its pedicle and ligated

The surgeon now places the strangulating silk ligature against the longitudinal muscle in the depths of the wound at the inner margin of the subcutaneous external sphincter. As the assistant makes radial tension on the forceps and the pile, the ligature is made to encircle the pedicle above the pedicle-holding forceps, together with the longitudinal muscle, and then tied (Fig. 197). As the ligature is being tied over the pedicle with strangulating force the pedicle-holding forceps is removed by the assistant to prevent its inclusion in the ligature. An artery forceps is put on the free ends of the ligature and they are held by the assistant with the skin-holding forceps and retracted throughout the operation. *Strangulating ligature*

The surgeon deals similarly in turn with the right anterior and right posterior haemorrhoid (Fig. 198).

Some operators prefer to transfix the pile pedicle and longitudinal muscle with a needle and use No. 4 catgut for a strangulating ligature.

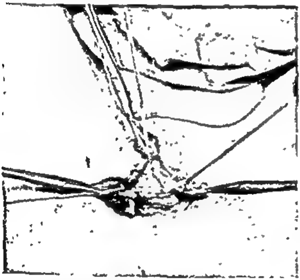


FIG 198.—All three haemorrhoids dissected and ligated Note intact skin "bridges" between ligated haemorrhoids.

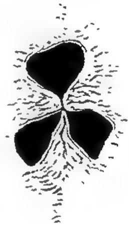


FIG. 199.—Dark areas represent the trimmed skin wounds after removal of the three haemorrhoids and returning the ligated pedicles to the bowel. Note intact skin bridges between the cuts.

As the skin cuts for each pile are made, notice should be taken of the previous skin cut so that adequate skin bridges are left. Indeed, the whole plan of operation, both "skin bridges" and "haemorrhoids removed", should be visualized after the exposure of the haemorrhoids and before the operation begins, for it is a different problem in each case The skin bridges need not be broader than ½ inch. Bridges which are too broad or too loose tend to become oedematous and leave post-operative skin tags. Distended veins under the skin bridges should be dissected out from under the skin. *Adequate skin bridges* *Dissection of distended veins*

The internal haemorrhoid and external haemorrhoid distal to the strangulating ligature are now removed with scissors, leaving enough tissue to

prevent slipping of the ligatures. The ligatures are cut short to ½ inch. The stumps of the ligated piles are restored to their place in the rectum by inserting a corner of gauze into the anal canal with the point of the scissors.

Trimming of edges

Three skin cuts with intervening skin bridges now present. With scissors and dissecting forceps the skin edges of each cut are trimmed. All loose undermined irregular and redundant edges are removed so that the wounds are left open, flat and triangular, in the best shape and condition to heal by second intention (Fig. 199). Any bleeding arteries are picked up with forceps and ligated. Oozing will cease.

Flattening of wounds

A small tube, ½ inch in diameter and 3 inches long, with a string attached is inserted into the rectum. It reveals concealed haemorrhage from slipping of the ligatures, allows "wind" to escape and keeps the wounds flat. Round the tube three small corners of Vaseline-covered gauze are inserted with the point of the scissors to flatten the wounds and bridges. Dry gauze is applied over all and dressings are fixed with a firm T bandage.

Secondary piles

Fissure-in-ano

Sometimes it seems inappropriate to include the anterior or posterior secondary piles, if present, in either of the ligatures of the primary piles; secondary piles can then be dissected off the subcutaneous external sphincter and ligated separately. As there is no pedicle, the pedicle forceps is applied to the internal haemorrhoid If there is accompanying fissure-in-ano calling for division of the subcutaneous sphincter ani muscle and a wide posterior wound, it is usual to be content with two skin bridges, one on each side of the right anterior pile.

8. POST-OPERATIVE TREATMENT

Aperient

The tube placed in the anal canal at operation is gently removed after 24 hours; the inserted gauze dressing is left in place. A moist gauze dressing of 1 : 80 carbolic acid or 1 : 40 Milton lotion is applied. This superficial dressing is changed three times daily. On the second evening after the operation a mild aperient is given, such as liquid paraffin, ½ ounce, and Cascara Evacuant, 1 drachm, or a double dose of the patient's usual aperient.

Enema

Removal of gauze

Next morning, the third morning after the operation, a 5-ounce olive-oil enema is given through a small rectal tube and funnel. The three pieces of gauze inserted at operation will usually come away or can be gently removed. If the dressing is very adherent it is kind to give intravenous Pentothal Sodium for its removal.

Wounds in this region heal with greater comfort if they are kept clean.

Baths and dressings twice a day are started and continued after the first bowel movement. The patient is now encouraged to practise and regain the regular unaided daily bowel rhythm after breakfast and so is weaned from his aperient before leaving hospital.

Dressings

With the patient on the left side and the buttocks lifted well out to project over the edge of the bed, a mackintosh is placed under the patient and a dressing pail receives the washings. The small skin wounds are irrigated and cleansed with a stream of antiseptic lotions (Milton 1 : 40, Dettol or carbolic

acid 1 : 80) from a funnel and tube or a douche can after the bath. The area around the sensitive skin wounds is gently swabbed.

A corner of moist gauze is gently tucked about ½ inch into the anal canal with sinus forceps and the excess arranged lightly over the wound outside. The aim is to keep the three skin wounds flattened by dressing. Any tendency of the skin to "bridge over" must be counteracted by dressings.

It is advisable to pass a finger into the rectum on the seventh day and at intervals of 3 days afterwards. This is a wise precaution and the little finger at first gives less pain. The shedding of the silk ligatures and an empty rectum are noted. If there is a tendency to spasm or constriction a St. Mark's anal dilator should be passed daily. This has become a routine procedure at St. Mark's Hospital from the seventh day until the wounds are healed. Constriction rings and muscular spasm are thus avoided. Wounds are kept flat. *Spasm or constriction*

The skin wounds take 3–6 weeks to heal. The patient, now on holiday or at work, attends at weekly intervals till healing is complete. It is not necessary to remain longer than two weeks in hospital.

9. POST-OPERATIVE COMPLICATIONS

(1) Pain

This varies from discomfort to severe distress in a few patients. In all cases it is well to prescribe injections of morphine, ¼ grain, and compound tablets of codeine to be repeated when necessary for the first 2 days. Relief follows the removal of the tube and the inserted dressings Relief is also obtained from baths. *Morphine*

Pre-operative injections of Proctocaine into the perianal space cannot be relied on to relieve pain in all cases so it has been abandoned as a routine procedure.

(2) Retention of urine

This complication occurs in about 2·5 per cent of cases All the usual nursing methods are adopted before resort is made to drug and catheter treatment The patient should be encouraged to pass urine after the operation so that the bladder does not become over-distended. Removal of the tube and allowing the patient to attempt to pass urine in the toilet will help in difficult cases.

The presence of an enlarged prostate in elderly men should always be borne in mind before and after operation. Injections of carbachol should be tried before catheters are used. *Enlarged prostate*

(3) Reactionary and secondary haemorrhage

Haemorrhage occurring soon after the patient returns to bed usually comes from the skin cuts. The bleeding artery can be seen and ligated. Haemorrhage from a slipped pedicle ligature can be detected by the blood coming from the tube in the rectum. This bleeding is more serious and the patient may show general signs of blood loss The pedicle and bleeding vessels must be caught with forceps and ligated; for this the patient will have to return to the theatre. *Slipped pedicle ligature*

Secondary haemorrhage is rare; Gabriel (1948) found 0·5 per cent to be the incidence. It occurs from the fifth to the twelfth day. Copious concealed *Secondary haemorrhage*

haemorrhage into the rectum can occur. The patient becomes pale and faint and perhaps passes blood. Examination of the rectum reveals the presence of blood.

Treatment

A strong sedative is given. A rubber tube, ½–¾ inch in diameter and 4 inches long, surrounded at one end with dry gauze strips is inserted into the rectum through a tubular proctoscope after the blood has been washed out of the rectum. As the gauze surround enters the rectum the speculum is withdrawn leaving the rubber tube emerging from the anus. A large safety-pin is passed through the tube immediately outside the anus and a gauze strip 12–24 inches long is passed round the tube between the pin and the anus to maintain pressure on the site of the haemorrhage at or about the ano-rectal ring.

Pressure

The foot of the bed is raised on blocks. The patient is left on his side and the tube inspected at intervals. The half-hourly pulse rate is recorded. Blood transfusion may be necessary.

Transfusion

The tube and surround are removed in 48 hours, after an injection of morphine, ¼ grain. An injection of 5 ounces of olive oil into the rectum through the tube facilitates its removal. A piece of plain tubing is left in the rectum for another 12 hours. Laxatives will keep the motions soft and the patient should be kept in bed for a week after the haemorrhage.

Laxatives

(4) Constriction rings

Constriction rings can occur at the site of the ligature in the rectal mucosa at the ano-rectal ring, or at the anus at the site of the skin cut. The former is easily and painlessly treated by weekly dilatation with finger or dilator. The constriction at the anus is painful and resistant to dilatation and may need operative treatment. This condition should be avoided by leaving adequate skin bridges at the time of operation Fortunately constriction rings are now rarely seen when haemorrhoidectomy is carried out with due regard to surgical principles and experience.

(5) *Post-operative skin tags*

These also are now rare if care is taken to remove the redundant skin of the anus and the external haemorrhoidal plexus, as well as to leave narrow bridges between flat skin wounds. Should skin tags occur and worry the patient they can be excised later under local anaesthesia.

Excision

(6) Abscess and fistula formation

In very rare instances a submucous or subcutaneous abscess or fistula may occur due to infection or to the failure of the wound to heal by second intention. Care to keep wounds flat by dressings and dilator prevents this complication. Inspection with a probe will detect a fistula. It should be treated surgically.

10 INJECTION TREATMENT OF HAEMORRHOIDS

(1) The solution

The solution used is 5 per cent phenol in almond oil with 2 grains of menthol to the ounce. This solution is safe, effective, and has stood the test of many years' trial. The average amount to inject into each of the three piles at one

visit is 3 cubic centimetres of the solution, but in large piles 6 cubic centimetres can be used. Some have injected 10 cubic centimetres into a single large pile.

The use of glycerin solutions should be abandoned as they are too frequently followed by intense pain and serious haemorrhage.

(2) The site

The injection is made into the submucous space of the internal pile or of its pedicle. If prolapse is the main symptom the pedicle should receive the injection. If bleeding is the main symptom then the internal pile itself should be distended with the solution. Each of the three primary piles is injected at the one time. It is not necessary to apply an antiseptic to the site of the injection.

The first injection is made at about the level of the ano-rectal ring. The ano-rectal ring is demonstrated by withdrawing the proctoscope from the rectum into the anal canal. Various types of needle and syringe are used such as Gabriel's syringe with finger grip or an eccentric 10-cubic-centimetre Record syringe with a special long needle.

(3) Technique of injection

With the patient in the knee-chest position, a good light and a tubular proctoscope (St Mark's pattern) are used After the finger has been inserted and the rectum examined, the lubricated speculum is passed into the rectum and air is allowed to distend the organ, then the speculum is withdrawn to the anal canal. The first or upper part of the anal canal to prolapse into the speculum, forming a ring of mucosa, is the ano-rectal ring. The speculum is further withdrawn about ½ inch and then pressure exerted upwards a little. This makes the haemorrhoids more conspicuous. They can be examined; their size and relation to the pedicle is noted.

The needle is now inserted obliquely through the thin rectal mucosa just above or at the level of the ano-rectal ring. It is inserted with a little jerk or stab and can be felt to pierce the mucosa and enter the submucous space (Fig 200). A sharp needle is essential. As the solution is injected into the space, bulging of the mucosa is noted, for if the needle

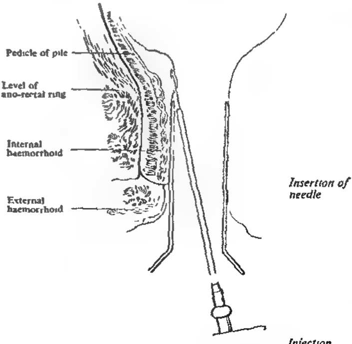


FIG 200—Diagram to show the site of the injection of the sclerosing solution into the submucous space and the extent of spread (shaded area).

has not quite entered the space the mucous membrane will become bl
If the needle has gone deeper through the space into muscle no bulg
occur. The *solution freely spreads in the submucous space upwards* pedicle, downwards into the pile and around the anal canal to the se piles. Its spread downwards is limited by the intermuscular septum a does not enter the sensitive perianal space below.

Area of spread

The right anterior pile is injected first, then the right posterior anc the left lateral. Swinging the proctoscope from side to side is an exposing and fixing the pile for injection. If bleeding occurs at the *puncture it will soon stop.*

Discomfort

The patient should be warned that sometimes there is discomfort feeling of fullness during injection, but it will soon pass off; also tha sionally there is some after-pain lasting for an hour or two. Rest in sedative and a hot bath will give relief. The bowel action should be till the next morning.

All three piles are injected again at 3-week intervals, this period *allowed for the resulting inflammation and its partial resolution.* symptom of prolapse is not relieved after three visits it is unwise to co and operation must be considered. If the prolapse or bleeding returr an interval of freedom, then it may be desirable to repeat the injecti in the first instance.

(4) Pathology of injection treatment

Aseptic inflammation follows injection with an immediate firm swel the pile by inflammatory products. Fibrosis and thrombosis of blood- occur. The mucous membrane covering internal piles and pedicles is to the subjacent muscles. The submucous space is obliterated.

Fibrosis and thrombosis

Immediate clinical results are good, bleeding ceases at once and the p and the pile become firm and fixed. Prolapse now ceases. Subseq however, resolution takes place and the symptoms may recur.

Resolution

In attempting to give second injections it is often found that an a submucous space is obliterated by the results of the previous injectic free submucous space *will be found with the needle on either side* indurated pile where another injection can be given.

Sloughing

Sloughing may occur if injection is made into already sclerosed tissue

(5) Complications

Complications from injections are extremely rare and if the injectior

Injection ulcer

present-day technique and solution. *Injection treatment should* undertaken by those unpractised in rectal examination and unfamiliar rectal anatomy and pathology.

11. CHOICE OF TREATMENT AND SELECTION OF CA

In suitable cases injection treatment may relieve symptoms for montl years and the patient may remain quite comfortable. It will arrest hae rhage in nearly all cases of first-degree haemorrhoids and should be repe

t degree

if bleeding recurs. It is the treatment of choice in these cases. In about three-quarters of the number of cases with second-degree piles injection treatment will stop prolapse and should be advised in all such cases, that is in piles which only prolapse on defaecation. *Second degree*

Relief of third-degree haemorrhoids, piles which prolapse during the day, is not to be expected from injection treatment and for these operation is advised at the outset. When piles are complicated by fissure-in-ano, fistula or fibrous anal polypi, operation is the treatment of choice. It should ever be borne in mind that the injection treatment and operative treatment are the only effective treatments in piles. Medicines, ointments, and so on only alleviate the symptoms, for haemorrhoids are a developmental and progressive disease. *Third degree*

In advanced cases of the second-degree and in all third-degree piles the fact that operative removal is final, radical and without recurrence should weigh the scales in favour of operation. A patient can be assured that his rectal condition and function will be restored to normal.

Young people, men in the Forces, and travellers to remote places abroad should not be allowed to face their active and formative life handicapped and preoccupied with piles and the resulting difficulties in defaecation. For them operation is the treatment of choice Middle-aged people should be prevented from entering old age with this avoidable torment to add to their infirmities. Women troubled in a previous pregnancy by haemorrhoids should ensure by operation or injection that trouble will not recur in subsequent pregnancies.

There are but few diseases in which patients are so grateful for the relief gained by operation. Work and thinking are improved, relationships at home, at work and in society are bettered. Depression is replaced by a feeling of well-being and hope, fatigue by a sense of vigour. With the knowledge of these benefits operation can be urged in suitable cases.

12. COMPLICATIONS OF HAEMORRHOIDS

(1) Perianal haematoma or external thrombosed pile

This may occur as a sudden painful rounded tense swelling under the sensitive skin of the anus or anal canal, sometimes spontaneously, sometimes following straining. It is a haemorrhage from the external haemorrhoidal plexus and the dark blood clots can often be seen under the skin Sometimes the tense skin breaks and the blood clots exude If multiple, the swellings may occupy half the circumference of the anus, several clots can be palpated and the skin may become oedematous. The pain subsides after 4 or 5 days and is often subsiding when the patient seeks advice. A harmless skin tag may be left after absorption

Patients seek treatment because of the pain and swelling. Relief can be obtained at once by excision under local anaesthesia, but as pain will always subside in a few days and patients usually delay consultation, treatment by rest, warm applications, hot baths and sedatives is then preferred and there is no wound to granulate as after excision. Which treatment to adopt depends on the size of the pile, the time of onset, and the amount of suffering experienced. If the pile is situated in the midline anteriorly or posteriorly *Treatment*

has not quite entered the space the mucous membrane will become blanched. If the needle has gone deeper through the space into muscle no bulging will occur. The solution freely spreads in the submucous space upwards into the pedicle, downwards into the pile and around the anal canal to the secondary piles. Its spread downwards is limited by the intermuscular septum and so it does not enter the sensitive perianal space below.

Area of spread

The right anterior pile is injected first, then the right posterior and finally the left lateral. Swinging the proctoscope from side to side is an aid in exposing and fixing the pile for injection. If bleeding occurs at the site of puncture it will soon stop.

Discomfort

The patient should be warned that sometimes there is discomfort and a feeling of fullness during injection, but it will soon pass off; also that occasionally there is some after-pain lasting for an hour or two. Rest in bed, a sedative and a hot bath will give relief. The bowel action should be put off till the next morning.

All three piles are injected again at 3-week intervals, this period being allowed for the resulting inflammation and its partial resolution. If the symptom of prolapse is not relieved after three visits it is unwise to continue, and operation must be considered. If the prolapse or bleeding returns after an interval of freedom, then it may be desirable to repeat the injections as in the first instance.

(4) Pathology of injection treatment

Fibrosis and thrombosis

Aseptic inflammation follows injection with an immediate firm swelling of the pile by inflammatory products. Fibrosis and thrombosis of blood-vessels occur. The mucous membrane covering internal piles and pedicles is "fixed" to the subjacent muscles. The submucous space is obliterated.

Resolution

Immediate clinical results are good, bleeding ceases at once and the pedicle and the pile become firm and fixed. Prolapse now ceases. Subsequently, however, resolution takes place and the symptoms may recur.

In attempting to give second injections it is often found that an area of submucous space is obliterated by the results of the previous injection. A free submucous space will be found with the needle on either side of the indurated pile where another injection can be given.

Sloughing

Sloughing may occur if injection is made into already sclerosed tissue.

(5) Complications

Injection ulcer

Complications from injections are extremely rare and if the injections are [illegible] occur and [illegible] present-day technique and solution. Injection treatment should [illegible] undertaken by those unpractised in rectal examination and unfamiliar with rectal anatomy and pathology.

11. CHOICE OF TREATMENT AND SELECTION OF CASES

First degree

In suitable cases injection treatment may relieve symptoms for months or years and the patient may remain quite comfortable. It will arrest haemorrhage in nearly all cases of first-degree haemorrhoids and should be repeated

if bleeding recurs. It is the treatment of choice in these cases. In about three-quarters of the number of cases with second-degree piles injection treatment will stop prolapse and should be advised in all such cases, that is in piles which only prolapse on defaecation. *Second degree*

Relief of third-degree haemorrhoids, piles which prolapse during the day, is not to be expected from injection treatment and for these operation is advised at the outset. When piles are complicated by fissure-in-ano, fistula or fibrous anal polypi, operation is the treatment of choice. It should ever be borne in mind that the injection treatment and operative treatment are the only effective treatments in piles. Medicines, ointments, and so on only alleviate the symptoms, for haemorrhoids are a developmental and progressive disease. *Third degree*

In advanced cases of the second-degree and in all third-degree piles the fact that operative removal is final, radical and without recurrence should weigh the scales in favour of operation. A patient can be assured that his rectal condition and function will be restored to normal.

Young people, men in the Forces, and travellers to remote places abroad should not be allowed to face their active and formative life handicapped and preoccupied with piles and the resulting difficulties in defaecation. For them operation is the treatment of choice Middle-aged people should be prevented from entering old age with this avoidable torment to add to their infirmities Women troubled in a previous pregnancy by haemorrhoids should ensure by operation or injection that trouble will not recur in subsequent pregnancies

There are but few diseases in which patients are so grateful for the relief gained by operation. Work and thinking are improved, relationships at home, at work and in society are bettered. Depression is replaced by a feeling of well-being and hope, fatigue by a sense of vigour. With the knowledge of these benefits operation can be urged in suitable cases

12. COMPLICATIONS OF HAEMORRHOIDS

(1) Perianal haematoma or external thrombosed pile

This may occur as a sudden painful rounded tense swelling under the sensitive skin of the anus or anal canal, sometimes spontaneously, sometimes following straining It is a haemorrhage from the external haemorrhoidal plexus and the dark blood clots can often be seen under the skin Sometimes the tense skin breaks and the blood clots exude. If multiple, the swellings may occupy half the circumference of the anus, several clots can be palpated and the skin may become oedematous. The pain subsides after 4 or 5 days and is often subsiding when the patient seeks advice. A harmless skin tag may be left after absorption

Patients seek treatment because of the pain and swelling. Relief can be obtained at once by excision under local anaesthesia, but as pain will always subside in a few days and patients usually delay consultation, treatment by rest, warm applications, hot baths and sedatives is then preferred and there is no wound to granulate as after excision. Which treatment to adopt depends on the size of the pile, the time of onset, and the amount of suffering experienced. If the pile is situated in the midline anteriorly or posteriorly *Treatment*

it is unwise to excise it for the fear of producing a fissure which will not heal.

(2) Prolapsed thrombosed piles

In this condition the prolapsed internal and external haemorrhoids have not been replaced by the patient and because of the contracting sphincters the venous return through the pedicle is impeded. Swelling, thrombosis and haematoma have occurred, affecting both internal and external haemorrhoids which may be so "set" with exudate that they cannot, when seen, be returned

Gangrene to the anal canal. If the arterial supply is cut off, gangrene, usually superficial and limited to the covering of the pile, occurs, although mass gangrene may be seen. One or all three haemorrhoids may be affected.

The accident occurs before the patient has learnt to reduce his prolapsed piles or has neglected to do so The condition is easily recognizable if the surgeon identifies the particular epithelial coverings of the parts of the haemorrhoid. The prolapsed swollen internal haemorrhoid will be identified by its moist, red plum-coloured mucosa and the external haemorrhoid by its characteristic skin of anal canal and anus. As they are prolapsed piles of the second degree a deep groove will be demonstrated with a probe, between the internal and external haemorrhoids, caused by the still intact intermuscular septum.

Attempts to reduce the piles should be discontinued if the piles are tense and "set". They will gradually subside and return to the anal canal when resolution and re-establishment of the circulation occurs. Even the previous symptoms of bleeding and prolapse are at times relieved by the strangulation

Fibrosis of thrombosed piles may sometimes occur, giving rise to an anal polypus which subsequently should be removed. Often skin tags round the anus remain as evidence of the attack.

Third-degree piles rarely thrombose.

Treatment

It is not usual practice to operate on these cases although in exceptional circumstances, when there is no gangrene or infection but a purely vascular complication, operation might be done in safety. It is usual to adopt expectant treatment and to allow resolution to occur. Replacement under anaesthesia may be attempted.

In the acute stage rest in bed, compresses with lead lotions and alternating warm moist dressings, together with hot baths and sedatives, relieve the pain and promote resolution and restoration. In 3 weeks the end-result of treatment should be reviewed and further treatment mapped out. If prolapse or bleeding persists, either injection or operation should then be advised.

(3) Infection of piles

This may follow a haematoma or occur w ... ious cause. It is strikingly
rare when it is co ... t this is a b ... ted area. A submucous
or perianal absce ... calls for ... ery rarel inflammation
ends in gangrene, ... omplicati ... ay ca ... mporary
colostomy and ene ... herapy.

BIBLIOGRAPHY AND REFERENCES

Anderson, H. G. (1924). *Practitioner*, **113**, 399.

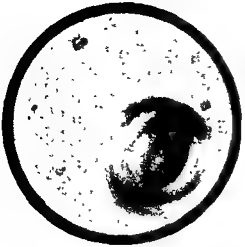
Blanchard, C. E. (1928). *Text boo of Ambulant Proctology*, p. 134. Youngstown, Ohio; Medical Success Press.

Gabriel, W. B (1948). *The Principles and Practice of Rectal Surgery*, 4th ed. London, Lewis.

Miles, W. E (1919). *Surg. Gynec. Obstet.*, **29**, 497.

Milligan, E. T. C., Morgan, C. N., Jones, L. E., and Officer, R. (1937) *Lancet*, **2**, 1119.

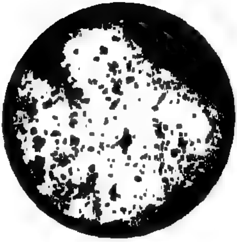
[References to other titles are given under Rectum—Haemorrhoids in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol 10, p. 502.]



(a)

(b)

(c)



(d)

(e)

PLATE II

(a) Granular colo-proctitis, no ulceration, and elasticity of bowel preserved. *(b) Ulcerative colo-proctitis*, presenting deep ulcers, loss of dilatation of bowel, and granular polypi (*c*) Close-up view of ulcerative colo-proctitis showing exposure of circular muscle and destruction of mucosa (*d*) Proctoscopy showing acute amoebic dysentery with thrush-like appearance resembling that of ulcerative colitis, *Entamoeba histolytica* in faeces. (*e*) Proctoscopy showing chronic amoebic dysentery with "pigskin pittings" seen on lax reticulated mucosa; *E. histolytica* cysts in faeces. ((*a*) (*b*) and (*c*) *by courtesy of Mr. E T. C. Milligan, (d) and (e) by courtesy of Sir Philip Manson-Bahr.*)

introduction of foreign bodies or the administration, in error, of corrosive solutions will cause proctitis. Rectal anaesthetic solutions such as ether, paraldehyde and Avertin can also bring about this condition.

A local ulcer in the lower part of the rectum may result from faulty technique in the treatment of haemorrhoids. A form of proctitis which may be considered under this heading is that associated with radiation therapy. Irradiation of the pelvic viscera for malignant disease may produce oedema and diffuse reddening of the rectal mucosa, and finally ulceration of the anterior wall. There is usually a history of radiotherapy having been given some months previously. The patient complains of bleeding from the rectum, tenderness, rectal pain and the passage of mucus. On examination the mucous membrane, generally in the middle third of the anterior wall, is reddened and bleeds easily. Bleeding persists and later telangiectases develop. Finally, an ulcer forms on the front of the rectal wall which may lead to a recto-vaginal fistula. The ulcer is usually single and if the pelvic carcinoma is controlled, will finally resolve, leaving a mild degree of stricture formation.

Radiation therapy

Examination

Recto-vaginal fistula

4. INFLAMMATORY PROCTITIS

(1) Bacillary dysentery

Sometimes bacillary dysenteric inflammation appears in an acute form limited to the rectum. This gives rise to a granular proctitis and the patient passes blood and mucus. Superficial ulcers form and the bacillus can be isolated from rectal swabs. Cultures made direct from the ulcers are more likely to be successful than a microscopic examination of the faeces If a local lesion in this infection persists and becomes chronic, it is still possible to isolate the organism from the ulcers.

Isolation of bacillus

(2) Amoebic dysentery

This is a more chronic infection and it is thought that the dysenteric symptoms depend upon a secondary bacterial infection. When the rectum is involved, tenesmus and straining are complained of. The rectal mucosa becomes raised into nodules which break down leaving small yellow ulcers with surrounding hyperaemia, the intervening mucous membrane remaining healthy. Sigmoidoscopic examination can be conducted without an anaesthetic. In contrast to what obtains in the chronic bacillary form, instrumentation is practically painless. The ulcers can be scraped and from these scrapings amoebae can be demonstrated. Occasionally, the hypertrophic type producing an amoeboma or amoebic granuloma is found. These closely resemble carcinoma but are fortunately rare (Morgan, 1944).

Sigmoidoscopy

(3) Lymphogranuloma venereum

The rectum can become involved by lymphatic spread from the initial site of the virus infection in the inguinal region, producing at first a proctitis and later stricture formation. The diagnosis is made by the response to the intradermal injection of Frei antigen and by finding enlarged lymph glands in the inguinal regions.

Diagnosis

(4) Bilharziasis

The intestinal form of bilharziasis is caused by *Schistosoma mansoni*, gives rise to dysenteric symptoms, may produce changes in the rectum, and may be

Schistosoma mansoni

associated with dermatitis and an enlarged spleen and liver. Mucus and blood are passed, and tenesmus is complained of. The rectum shows thickening of the mucosa and often papillomas and ulcers develop. These growths may be felt on rectal examination and are apt to be mistaken for internal piles (Manson-Bahr, 1939). When attaining large size they will prolapse through the anus. The characteristic lateral-spined eggs of *S. mansoni* are seen in a portion of mucosa removed and examined under the microscope.

(5) Tuberculous proctitis

Biopsy

Manifestations of this condition are apparent around the anal canal; clinical and radiological signs of pulmonary tuberculosis are present. A biopsy will confirm the diagnosis.

(6) Gonococcal proctitis

This occurs in both sexes from coitus, and in the female as a direct extension of infection from cervicitis or urethritis. Perianal abscess is not uncommon.

(7) Secondary proctitis

Sign of inflammation

This follows the rupture of a pelvic abscess into the rectum. As a sequel to appendicitis with pelvic peritonitis this is not unusual in childhood. It usually clears up spontaneously. Before rupture an excess of mucus is passed in the stools and this is a constant sign of inflammation adjacent to the bowel. Post-operative ulceration in connexion with haemorrhoidectomy will cause this condition, and spread of infection into the rectum from diverticulitis of the sigmoid may also be included under this heading.

5. NEOPLASTIC PROCTITIS

(1) Innocent tumours

Colonic polypi

Innocent tumours of epithelial origin such as adenoma or papilloma are not uncommon. These may be associated with irritation of the rectum resulting in a mucous discharge. Polypi of the colon may extend into the rectum and set up an irritation, so care must be taken in arriving at a correct diagnosis, in order that treatment in these cases may be focused on the colon rather than on the rectum.

(2) Malignant tumours

In the early stage carcinoma may simulate a proctitis before a definite tumour formation is recognized. In the later stages malignant disease is always accompanied by a proctitis

6. DIAGNOSIS

A careful examination of the rectal discharge by a pathologist will reveal the cause of a specific proctitis and will lead to the appropriate form of treatment. A granular proctitis of non-specific type will be accompanied by a profuse discharge of blood and pus and further investigations will be necessary (*see* Colitis in Vol. 3, p. 88).

Proctoscopy and sigmoidoscopy

Appearance of surface

The rectum, in proctitis, has a velvety surface, glistening with a layer of mucus and showing a granular appearance. Bleeding is easily induced either

by the passage of the instrument or by touching the surface Examination of the discharge shows either blood-stained mucus or quantities of muco-pus. The changes may remain limited to the rectum, though frequently they extend into the colon.

7. TREATMENT

(1) Specific types

The treatment of the specific types of proctitis will not be described. Details will be found under the appropriate titles.

(2) Non-specific types

If there is a localized rectal lesion, great stress must be laid on rest, diet and blood transfusions. Diet must be nourishing with an adequate amount of protein and vitamins but avoidance of roughage A milk diet is usually not well tolerated. Blood transfusions are of the greatest value, not only to overcome the varying degrees of anaemia, but to raise the low plasma protein. This can also be effected by administration of plasma to overcome the great loss of protein from the bowel and its associated negative nitrogen balance. *Nourishing diet* *Transfusions*

(a) *Intra-rectal medication*

Many solutions have been recommended but results are not uniformly satisfactory. Irrigation with saline is valuable. Astringents such as tannic acid and cod-liver oil emulsion are also used. Warm olive oil retained in the bowel is sometimes beneficial. *Irrigation*

(b) *Sulphonamides*

Retention enemas of succinylsulphathiazole or sulphaguanidine are of the greatest value; 6 grammes in 170 millilitres of water and mucilage can be run into the bowel and the patient is asked to retain this for as long as possible. The foot of the bed should be raised, and phenobarbitone should be given by mouth if necessary. With such assistance the period of tolerance can be increased gradually up to 6 hours. *Enemas*

(3) Surgical treatment

Surgical treatment is called for only when complications arise. Perianal or ischiorectal abscesses will require drainage. In chronic cases, and when there is stricture formation, proctotomy is performed.

Colostomy

This is resorted to only as a temporary measure when dealing with gross ulceration or stricture formation.

BIBLIOGRAPHY AND REFERENCES

Heilman, F R. (1946) *Proc. Mayo Clin.*, 21, 237.
Helper, M , and Szilagyi, D. E. (1942). *Amer. J. Roentgenol*, 48, 179.
Kornblith, B. A. (1946). *N.Y. St. J. Med.*, 46, 1358.
Manson-Bahr, P. H. (1939) *The Dysenteric Disorders, the Diagnosis and Treatment of Dysentery, Sprue, Colitis and other Diarrhoeas in General Practice.* London; Cassell.
— (1945). *Manson's Tropical Diseases*, 12th ed London; Cassell.

Morgan, C. N. (1944). *Brit. med. J.*, 2, 721
Norbury, L. E. C. (1946) *Post-grad. med. J.*, 22, 371.
Randall, L. M., and Buie, L. A. (1943) *Amer. J. Obstet. Gynec.*, 45, 505.
Todd, T. F. (1938). *Surg. Gynec. Obstet.*, 67, 617.
Wright, L. T., Berg, B. N., Bolden, J. V., and Freeman, W. A. (1946). *Surg. Gynec. Obstet.*, 82, 449.

[References to other titles are given under Rectum—Proctitis, in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol. 10, p. 524.]

RECTUM—PROLAPSE

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1. DEFINITION

293.] Prolapse of the rectum is a protrusion of the rectal wall through the anal orifice. This protrusion may be partial, consisting of mucous membrane only, or complete, when all layers of the rectum are involved.

The division of complete prolapse into numerical degrees is unnecessary and has led to confusion. Recto-sigmoid intussusception, also known as third-degree prolapse, characteristically does not protrude through the anal orifice and does not come under the scope of the definition. It is uncommon and has been fully described by Monsarrat (1926).

2. AETIOLOGY

(1) Partial prolapse

Partial prolapse is seen at the extremes of life. In children eversion of the anal mucosa during defaecation is physiological. If this eversion is repeated many times in 24 hours, as in diarrhoea, or maintained during long periods *In children*

of straining, as in constipation, it becomes exaggerated and the rectal mucosa starts to protrude. Neglect to train a child in the after-breakfast habit results in constipation, and administration of purgatives to correct the latter results in diarrhoea.

Partial prolapse may occur during the course of common childhood illnesses, for example, as a result of diarrhoea in gastro-enteritis, the irritation of threadworms, or increase of intra-abdominal pressure in whooping-cough. Prolonged illnesses and wasting diseases reducing the supporting areolar tissue of the rectum predispose to the condition. Mental deficiency renders a child unresponsive to bowel training.

In adults

In adults, partial prolapse is usually the result of confluent haemorrhoids, but may be seen as a sequel of Whitehead's operation or of operations for extensive fistulae.

In old people general tissue atrophy and loss of much tone produce a definite group of cases. Loss of fat from the ischio-rectal fossae and lax atonic sphincters characterize this group.

In males, straining from prostatic obstruction, and in females damage to the perineum at childbirth, are undoubtedly contributory factors. Prolapse of rectal mucous membrane may occur during the course of amoebic dysentery. Failure to recognize the underlying pathology may result in disaster if the condition is treated surgically. Adequate anti-amoebic treatment will lead to spontaneous cure.

Amoebic dysentery

(2) Complete prolapse

Age and sex incidence

Complete prolapse is commonly seen in 3 main age-groups: in early childhood, in young adults and in a later group with an incidence peak at 55 years of age. The ratio of females to males is 6:1. The ratio of married to single females is 2:1.

The aetiology of complete prolapse is best understood by accepting Moschowitz's theory and by regarding the condition as a sliding hernia of the rectum through the pelvic musculo-fascial diaphragm (Moschowitz, 1912). In common with other hernias, two main factors are responsible for their production. These factors are a weak spot in the wall of the containing cavity, which may be congenital or acquired, and increased pressure in the cavity.

Muscular weakness

The weak spot is the exit of the rectum through the pelvic diaphragm. In children and young adults there is probably a congenital defect or weakness in the muscles of the pelvic diaphragm with an abnormally low peritoneal pouch of Douglas. In the higher age-groups the weak spot is probably acquired. Middle-aged men and women in sedentary occupations are liable to weakness of the abdominal and pelvic musculature due to insufficient exercise and fatty infiltration. These same factors produce the similar sliding hernias of the caecum and pelvic colon in the inguinal region. In females injury to the pelvic floor at childbirth may be a contributory factor.

Childbirth

It might be expected that the incidence of complete prolapse in single women should be the same as in men There is, however, a much higher incidence in single women than in men; this may be due to the wider architecture of the female pelvis.

Increased pressure

Increased pressure on the pelvic diaphragm is due to deposition of fat in the omentum and abdominal viscera (especially the pelvic colon and its

appendices epiploicae), straining from chronic cough, constipation and urethral obstruction.

Diseases of, and injury to, the spinal cord resulting in paralysis of the pelvic musculature and sphincter muscles may also result in a prolapsed rectum, and there is no doubt that a strong and efficient sphincter plays an important role in maintaining the rectum in place. *Spinal cord affections*

3. SURGICAL ANATOMY

(1) Partial prolapse

The protruding portion of bowel is 1–1½ inches long and consists of two layers of mucous membrane. The whole circumference may be involved, or more usually in adults the prolapse is confined to the right or left lateral quadrants.

(2) Complete prolapse

The protrusion is over 2 inches long and on an average 4–6 inches. It consists of two thicknesses of complete bowel wall and, between the two layers anteriorly, of a peritoneal pouch into which abdominal contents descend.

The starting-point of the prolapse is an invagination of the anterior rectal wall into itself at the peritoneal reflection just above the levator ani muscle. As it enlarges the lateral and posterior walls are dragged down. All the supports of the rectum, the lateral ligaments and the peritoneal folds between the rectum, sacrum, bladder and vagina, become stretched and elongated.

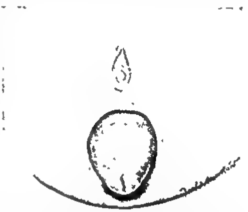


FIG 201 —Complete prolapse in a female Oedema has obliterated circular folds of mucosa, leaving the prolapse a dark shiny red

In advanced cases there is a wide gap in the levator ani muscle and its covering fascia sufficient for an adult fist to be passed through. The sphincter muscles of the anus and rectum become stretched and lose their tone and contractile power. In women there is frequently a degree of prolapse of the vaginal walls and occasionally a complete prolapse of the uterus (Figs. 201 and 202). *Vaginal and uterine prolapse*

4. CLINICAL PICTURE

(1) Symptoms

In children the prolapse is first noticed by the parent or nurse. A plum-coloured swelling may be seen or attention may be drawn to the condition by slight bleeding. The child rarely complains of discomfort. *In children*

The symptoms of partial prolapse in adults are those of the underlying condition together with the constant presence of prolapsed mucosa, bleeding, discharge of mucus and pruritus ani. *Partial prolapse in adults*

Complete prolapse

FIG. 202.—Complete uterine and rectal prolapse.

In complete prolapse the symptoms are more distressing. At first there is only a discharge of mucus followed by protrusion of the bowel on defaecation. Later the prolapse descends on the slightest exertion. Weakening of the sphincter renders control of function difficult, and finally the patient, incontinent of faeces and in constant discomfort, is confined to the house.

Mental disorder

There are two aspects of the clinical picture which deserve emphasis; first, sufferers with a complete prolapse will sometimes bear with the condition for a long period before seeking professional advice; secondly, rectal prolapse may be associated with mental disorder. There is no doubt that rectal prolapse occurs in mentally defective children; that adults are sometimes mentally substandard; that the condition is frequently seen in asylums; and that operations for rectal prolapse may be complicated by acute mania in the early post-operative period. With these facts in mind a careful assessment of the patient's mental capacity should be made before treatment is undertaken.

(2) Physical signs

Partial prolapse in children presents as a bluish-red swelling at the anus Folds, if present, radiate from a centrally placed lumen. In adults the prolapsed mucosa is red, smooth and shiny, being covered with a film of mucus. It may involve one or both sides, or more rarely the whole circumference.

The mucosa of a complete prolapse is arranged in a series of thick, circular folds (Fig. 203). Following reduction of a prolapse the following points may be noted. *Traction on the anal margins causes the anus to open and remain* patulous. Pressure on the perineum in front will effectively prevent the prolapse coming down in spite of the patient straining. Similar pressure posteriorly will *not* have the same effect. On inserting the finger into the rectum and asking the patient to strain, the anterior wall of the rectum will be noted to descend first.

5. COMPLICATIONS

Irreducibility

The complications of prolapse of the rectum are the same as those of any other hernia. *Irreducibility is the commonest complication* and is usually preceded by a period of constipation with oedema of the prolapsed bowel.

Most complete prolapses exhibit a degree of proctitis. In long-standing cases ulceration may occur. The mucosa loses its circular folds and becomes smooth and glistening with excess of mucus secretion. Gangrene may occur in neglected cases. It is interesting to note that the early attempts at amputation of a prolapse were made for this complication. Perforation of the anterior rectal wall with rupture of the hernial sac and escape of abdominal contents has been reported.

Inflammation

Gangrene

Perforation

6. DIAGNOSIS

The diagnosis of prolapse in children is not easy. First the child does not produce the prolapse to order. It is surprising how many cases, when admitted to hospital for observation, are subsequently discharged without the

In children

FIG. 203.—Complete rectal prolapse showing circular folds of mucosa.

prolapse being seen in spite of vigilance by the nursing staff over periods of several days. When the prolapse is seen it is often difficult to decide whether it is partial or complete.

In adults, a small complete prolapse is sometimes associated with haemorrhoids and it is not until the patient is under anaesthesia for haemorrhoidectomy, with traction applied to the pile pedicles, that the major lesion becomes apparent. Under these circumstances the surgeon is well advised to refrain from operating and to reconsider the case in all its aspects.

In adults

Prolapse can be secondary to other rectal lesions, such as large adenomas, villous tumours and carcinomas. This possibility emphasizes the importance of invariably adhering to a routine examination of inspection, digital palpation, proctoscopy, and sigmoidoscopy. The possibility of missing such an association then becomes improbable.

Secondary prolapse

7. PROGNOSIS

In children the prognosis is difficult to assess. This is partly due to the difficulty in deciding between the types of prolapse. From a few case-records of adults it is apparent that the prolapse is a legacy from childhood. Information that is lacking is the percentage of cases with rectal prolapse in childhood

that persist or return in adult life. The difficulties of such a long-term review are obvious.

Generally, however, the majority of cases in children are cured with common-sense regulation of the bowel habit. In adults spontaneous cure never occurs. Untreated partial prolapse remains an unpleasant though relatively minor discomfort. Complete prolapse progresses until the patient is a bedridden invalid, subject to the ever-increasing risks of complications.

8. INDICATIONS FOR SURGICAL TREATMENT

There are no indications for major surgical procedures for rectal prolapse in children. As already stated, spontaneous cure is common. The maximum local treatment ever necessary is submucous or perirectal injections, or the introduction of a perianal catgut suture. There is evidence to suggest that local treatment is successful, not by virtue of any particular injection solution or method of injection, but by causing pain at the sensitive anal region. This increases sphincter tone and discourages the extrusion of the prolapse.

Effect of local pain

The application of this observation to adults, by creating an artificial fissure-in-ano, has not the same result. Partial prolapse in adults is best treated by ligation and excision. Gabriel (1948) has distinguished between cases of partial prolapse with normal sphincter tone and those with sphincter relaxation, and has strongly advised against excision in this latter group, because recurrence is invariable. The majority of cases of complete prolapse in adults require one or more major surgical operations.

Thiersch's operation

The only minor procedure worth consideration is Thiersch's operation and, in the elderly group of patients over 70 years of age, this operation has special application. In the case of young and middle-aged patients fit to undergo lengthy abdominal operations, repair of the pelvic floor from below or above combined with obliteration of the pouch of Douglas is the rational treatment.

Difficulties in obesity

In the obese middle-aged patient the technical difficulties of abdominal pelvic operations are much increased. The fatty myocardium contra-indicates abdominal section. These cases can be treated by recto-sigmoidectomy with suture of the levator ani muscle.

The difficulty confronting the surgeon is the choice and application of methods to the wide range of patients who present for treatment.

Colostomy

Lastly, it cannot be too strongly emphasized that a well-constructed colostomy may be the treatment of election for those patients who have already had multiple unsuccessful operations and are incontinent.

9. TREATMENT

(1) In children

(*a*) *Bowel training*

Need for discipline

Treatment of rectal prolapse in children must be carried out, away from home, in hospital. The substitution of ward discipline for the care of anxious, irresolute parents is essential for success. It is remarkable that no prolapse is seen in many cases admitted to hospital for observation preliminary to treatment.

... should be made; the ...se has already

been mentioned. A great number of cases will respond to bowel-habit training and to a period of defaecation in the left lateral position.

A wide, flat board covered with rubber sheeting is laid across the bath. The rubber sheeting hangs down over the edge of the board into a bucket on the floor. The child lies on the board in the left lateral position with its head on a pillow, the buttocks projecting over the edge of the board and the knees and hips flexed. For the first week a small soap-and-water enema is given daily after breakfast. The child soon learns to defaecate spontaneously in this position and after a month may resume passing stools in the sitting position, using a narrow-slit toilet seat or similar chamber placed on the floor. The object is to avoid stretching out the buttocks and anal margins during defaecation. *Procedure for defaecation*

(b) Submucous injections

In cases in which the mucosa is very loose it can be fixed down. The simplest method of accomplishing this is by submucous injections of 5 per cent phenol in almond oil.

Operations on the anus and rectum in children are best done under atropine and Nembutal premedication and ether anaesthesia. With the child in the lithotomy position, the rectal mucosa is gently grasped with Babcock's forceps. If the prolapse can be drawn down a series of submucosal injections are made at the apex of the prolapse to form a ring of raised mucosa. A second ring of injections is then made at the base. If the prolapse cannot be drawn down a proctoscope is passed and the injection is given as for haemorrhoids. Up to 10 cubic centimetres may be used for each ring. *Position of patient*

(c) Perianal suture

If the prolapse descends frequently and easily the insertion of a perianal catgut suture is indicated A puncture incision 1 inch posterior to the anal margin is made with a tenotomy knife. Through this incision a length of No 3 chromic catgut is passed on a curved, round-bodied needle and made to encircle one half of the anus and emerge in the midline anteriorly; the needle is reinserted at the anterior puncture and passed round the opposite side of the anus to emerge again at the posterior tenotomy incision. With an assistant's little finger in the anal canal as a gauge to diameter, the catgut is tied and the knot buried. The tenotomy incision is closed with a single clip. *Incision*

(d) Other methods

Fixing the mucosa by linear cauterization or submucosal injections of absolute alcohol in doses of ½ cubic centimetre are methods with a personal preference and have no advantages. Extra-rectal injections of alcohol or phenol have been used to promote a fibrosis of the perirectal tissues and fixation of the rectum. The aim of treatment should be to effect a cure with the minimum of operative interference. *Linear cauterization*

(2) Partial prolapse in adults

(a) Ligation and excision

The patient is prepared as for haemorrhoidectomy. The prolapsing mucous membrane is grouped into 3 folds corresponding to the 3 primary haemorrhoids and the redundant mucous membrane is ligated and excised as in the operation for haemorrhoidectomy.

(b) Goodsall's stitch

This method is suitable when the prolapse is unilateral. Two curved, round-bodied needles are threaded one-third and two-thirds along a ligature of No. 3 chromic catgut. The prolapsing mucous membrane is transfixed so as to divide it into 3 equal parts. The catgut is divided at the needle eyes and

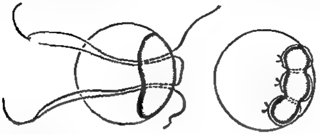


FIG. 204.—Diagram illustrating Goodsall's ligature with two needles.

the corresponding ends of the catgut are tied (Fig. 204). Redundant mucous membrane is then excised.

(3) Complete prolapse in adults

(a) General considerations

The treatment of complete prolapse is still an unsolved problem. Illustrated sections in surgical appliance catalogues of trusses for the control of rectal prolapse are a testimony to the failure of current surgical practice. This is not for the want of surgical attempt and effort. There are, indeed, over 40 surgical procedures which have been devised for this intractable complaint.

Surgical procedures

Broadly, they may be divided into operations designed to suspend or fix the rectum mechanically, such as the sigmoidopexies, rectopexies, injections and cauterizations, and operations planned to treat the condition rationally as a hernia. If the thesis that rectal prolapse is a hernia through the pelvic diaphragm is correct, then the principles of hernia surgery for its cure should apply, namely, removal of the hernial sac, repair of the internal ring and narrowing of the stretched external ring. In complete rectal prolapse this means removal or obliteration of the pouch of Douglas, repair of the defect or weakness in the levator muscle and its covering fascia, and a plastic operation on the sphincter ani muscle.

Hernia surgery

Operations have been described to effect all these surgical aims. Moschowitz's and Mayo's operations are designed to obliterate the pouch of Douglas. Graham's operation deals with the hernial sac and repairs the pelvic floor from above (Graham, 1942) Perineorrhaphy in its various forms has been used to repair the pelvic floor from below and is an important step in the operation described by Victor Bonney (1947) for rectal prolapse. Lastly, sphincter plication both from the front and from behind and the insertion of a perianal suture are practised to narrow and to strengthen the sphincter ani muscle.

Perineorrhaphy

In 1933 Miles standardized amputation of the rectum for prolapse and described the operation of recto-sigmoidectomy. The operation was safe, technically simple, could be generally applied, and it has remained as one of the standard operations for complete rectal prolapse.

It is now appreciated that the physiology as well as the mechanics of the problem deserve attention. The high recurrence rate and the failure of

Recurrence rate

the sphincter to recover tone and function have given rise to doubts whether removal of the rectum is desirable in rectal prolapse. There is evidence (Gaston, 1948) that the rectum is an important receptor organ and that it initiates the reflex arcs on which sphincter tone and function depend. If this receptor organ is removed, as in recto-sigmoidectomy, sphincter function and continence can hardly be expected.

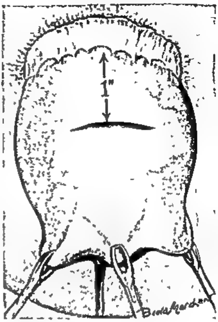


Fig. 205—Prolapse drawn down with Babcock's forceps. Site of initial circular incision shown.

There are, however, many cases of rectal prolapse which after recto-sigmoidectomy do not recur and which have a perfect mechanical and functional result. The pre-operative selection of these successful cases cannot yet be made with certainty but it is known that the best results with recto-sigmoidectomy will be obtained in the relatively young patient with a small or average-sized prolapse.

(*b*) *Pre-operative management*

The bowel is sterilized with phthalyl-sulphathiazole (Sulphathalidine), 5 grammes twice a day, for 5 days before operation. An enema is given the night before, and a rectal wash-out on the morning of the operation. In cases selected for recto-sigmoidectomy the patient's blood group should be checked and arrangements made for blood transfusion, because blood loss is sometimes considerable. *Blood transfusion*

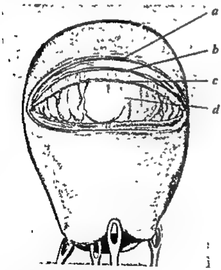


Fig. 206—Division of layers of rectal wall. The muscle layers should be divided at a lower level than the mucosa. The separate layers are more easily seen in oedematous bowel (a = cut edge of mucous membrane; b = cut edge of circular muscle; c = longitudinal muscle, d = extraperitoneal fat).

When repair of the pelvic floor or ventral fixation of the uterus is contemplated in women of the childbearing age, the question of sterilization must be discussed with the patient.

(*c*) *Recto-sigmoidectomy*

With the patient in the lithotomy position under general anaesthesia, the prolapse is grasped with tissue forceps and pulled down to its full extent (Fig. 205). *Position of the patient*

A circular incision is made through the outer layer of the prolapse at least one inch distal to the ano-rectal line (Fig. 206). The object is to leave that portion *Incision*

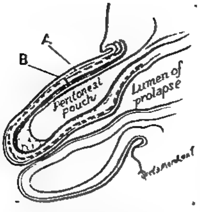


FIG. 207.—Diagram showing section of muscle layer B at a lower level than section of mucosa A, to allow for *retraction* of longitudinal muscle.

Haemostasis

of rectal wall adjacent to the anus, because it is this part in which the sensory stimuli of the sphincter reflex arc arise. Considerable bleeding from the submucous vessels will occur at this stage and the vessels should be secured and tied as they are cut. If the vessels are not tied at once the operator will be embarrassed by a large number of forceps hanging from the prolapse. As the incision is made a Babcock's forceps is placed on the bowel edge in the anterior, posterior, and two lateral positions.

The extraperitoneal fat is divided next and the peritoneal sac opened (Figs. 207, 208, 209). The recto-sigmoid bowel is grasped and as much pelvic colon as possible is

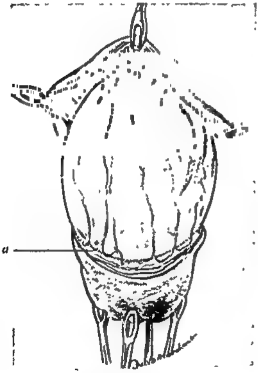


FIG. 208.—Circular incision completed Extraperitoneal fat and peritoneum exposed for section. a = outline of peritoneal pouch.

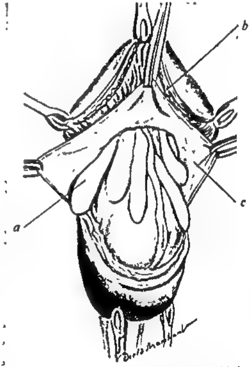


FIG 209.—Peritoneum opened and divided Note (a) fatty appendices epiploicae, (b) layers of rectal cuff; (c) peritoneum.

pulled down (Fig. 210). Before closing the peritoneum the edges of the levator ani muscle can be identified through the stretched dilated rectal cuff and approximated with sutures. This modification was suggested by Cohn (1942) and its use has been reported by Gabriel (1948) and Dunphy (1948). The peritoneum is now closed with No. 1 chromic catgut on an atraumatic needle, care being taken to close completely the deep lateral recesses (Figs. 211 and 212).

Closure of peritoneum

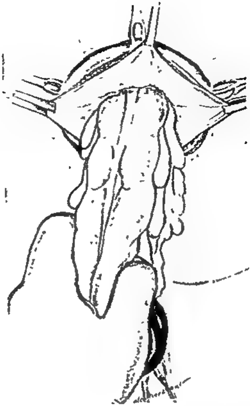


FIG 210.—Recto-sigmoid colon drawn down prior to re-suturing the peritoneum and section of bowel.

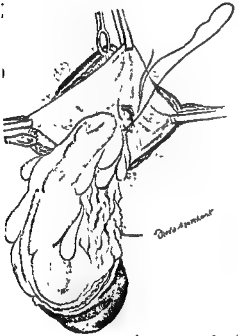


FIG 211—Suturing peritoneum A continuous running suture inserted on each side meeting in midline and tied separately. This avoids the stricturing purse-string effect of a single running suture Suture commenced on left.

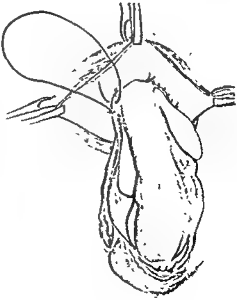


FIG. 212—Peritoneal suture inserted on left. Suture on right being completed.

FIG. 213.—Division of only ¾ of circumference of sigmoid colon, and insertion of stay sutures prevent retraction of the colon.

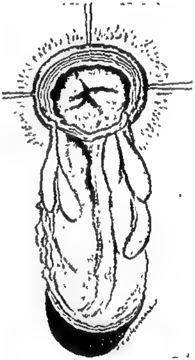


FIG. 214.—The anterior and two lateral stay sutures have been inserted Remainder of colon is now ready for division

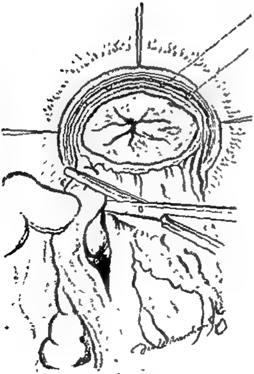


FIG 215.—Division of mesorectum and [illegible] prolapse (10–20 [illegible]

colon; in the short or average prolapse of 4–8 inches, after dividing sigmoid colon. Dotted lines show ligatures on vessels.

Next the pelvic colon is divided obliquely one inch distal to the anal margin in a downwards and forwards direction so as to leave a longer margin posteriorly than anteriorly. Before the posterior margin of the pelvic colon

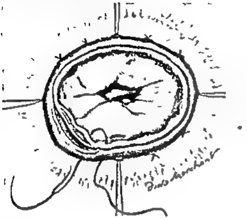


FIG 216—The final sutures uniting the edges of the bowel.

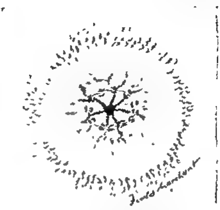
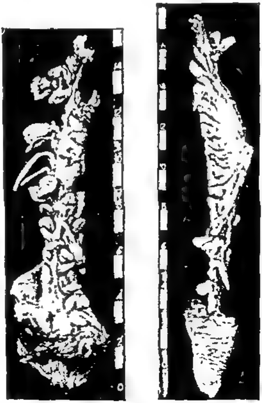


FIG 217.—Anastomosis replaced in anatomical position

is completely divided, 3 mattress sutures (Fig 213) are inserted between the rectal cuff and pelvic colon in the anterior and right and left lateral points (Fig. 214). This prevents any possibility of the colon retracting The posterior margin is now divided, exposing the mesocolon and superior haemorrhoidal vessels (Fig. 215) The bulk of fatty tissue is considerable and it is wise to subdivide the fat and vessels into pedicles suitable for ligation. *Sutures*

The remaining stay mattress suture is inserted in the posterior position and the edges of the bowel are united with a series of lightly tied interrupted No 1 chromic mattress sutures (Fig. 216). The sutured bowel is then returned inside the anus (Fig 217).

Fig 218 illustrates (a) the average-sized specimen and (b) the large extreme, measuring 21 inches, removed at recto-sigmoidectomy.



(a) (b)

FIG 218—(a) Average recto-sigmoidectomy specimen; (b) extreme recto-sigmoidectomy. Note large fatty appendices epiploicae.

(i) *Post-operative care.*—The bowels are confined for 5 days. On the fifth morning 2 glycerin suppositories are inserted into

the rectum and 5 minims of Cascara Evacuant are given 3 times a day till the bowels have acted. On no account should enemas be given post-operatively for fear of perforating the suture line.

Recto-vaginal fistula

(ii) *Complications.*—The posterior vaginal wall can easily be damaged during this operation, a recto-vaginal fistula resulting. A colostomy must be performed under these circumstances and not closed until the fistula is healed.

Separation of suture line

Separation of the suture line is not an uncommon complication and is usually confined to the posterior margin. Healing is invariable without the need for re-suture.

Secondary haemorrhage

If secondary haemorrhage occurs it is usually between the eighth and tenth post-operative day.

Stricture

The possibility of stricture formation in the early post-operative period makes a close watch essential. A finger is passed on the seventh post-operative day and at weekly intervals. The passage of Hegar's dilators up to size No. 22 will correct any tendency to stricture. The patient should not be discharged from supervision until the suture line is healed and supple.

(iii) *Results.*—A recurrence rate of 50 per cent can be expected if recto-sigmoidectomy is performed alone. At least 75 per cent of the total number of patients have imperfect sphincter function. They are usually incontinent to fluid faeces and flatus. Many complain they have 6 or more bowel actions on rising in the morning, passing small, hard, pellet-like faeces. Examination of the sphincter shows very little resting tone although the voluntary contractions are quite strong.

(d) *Repair of the pelvic floor*

This may be done from below through the recto-vaginal approach as in perineorrhaphy (McCann, 1928) or from above after division of the pelvic peritoneum (Graham, 1942)

(e) *Obliteration of the pouch of Douglas*

Moschowitz's operation consists of inserting a series of circular thread sutures in the peritoneum and fascia of the pouch of Douglas. These are then tied. Great care must be taken not to injure the ureters and, unless the surgeon is very familiar with pelvic surgery, it is advisable to pass ureteric catheters before commencing the operation. At its finish a rectal tube must be passed above the newly formed pelvic brim and sutured to the anal verge. It is left in for 5 days.

(f) *Thiersch's operation*

A strand of No. 20 gauge silver wire is passed round the anus in a similar fashion to the perianal suture in children. A hollow, curved serum needle can be passed round each side of the anus and the wire threaded through. The lumen of the anus is narrowed so that the proximal interphalangeal joint of an adult male index finger will just not pass through. Dickson Wright (1949) has recently applied this method to cases of complete rectal and uterine prolapse. The silver wire is made to encircle the anus and vagina in a figure of eight. Complete control has been achieved.

REFERENCES

Bonney, V. (1947) *A Textbook of Gynaecological Surgery*, 5th ed. London; Cassell.
Cohn, I. (1942) *Amer. J. Surg* , **57**, 444.
Dunphy, J E. (1948) *Surg. Gynec. Obstet.*, **86**, 434.
Gabriel, W. B. (1948) *Principles and Practice of Rectal Surgery*, 4th ed., p. 106. London, Lewis.
Gaston, E. A. (1948) *Surg. Gynec. Obstet* , **87**, 280, 669.
Graham, R. R (1942). *Ann Surg* , **115**, 1007.
McCann, F. J. (1928). *Lancet*, **1**, 1072
Miles, W. E (1933) *Proc. R. Soc. Med* , **26**, 1445.
Monsarrat, K. W. (1926). *Brit. J Surg* , **14**, 89.
Moschowitz, A. V. (1912). *Surg. Gynec. Obstet.*, **15**, 7.
Wright, Dickson (1949). In the press.

[References to other titles are given under Rectum—Prolapse, in the Index Volume. The subject ■ also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol. 10, p. 502.]

REFRIGERATION ANAESTHESIA

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1. INTRODUCTION

294.] Refrigeration anaesthesia is used, in the main, to remove a "dead" limb. It will be argued that an excess of cold damages living tissue and interferes with the natural processes of repair. The particular advantages in the method are that it is painless, shockless and well tolerated by the most aged and ill patients; it may be the safest of all unsafe methods for the gravely ill, for arteriosclerotic gangrene, for spreading diabetic gangrene, and for the embolic gangrene often associated with grave cardiac disease. It limits absorption from frankly decomposing or septic tissues and time is allowed for the preparation of the patient for the operation.

Advantages of method

The introduction of the antibiotic drugs has changed the outlook in many of these septic cases, and there are few that cannot thus be prepared and made fit for surgery but, even so, there does remain a small number of cases, particularly with associated cardiac or cerebral accidents, for whom a general anaesthetic, with the inevitable risk of some anoxia, adds to the operative hazard.

2. HISTORY

Fay (1940) sought to inhibit the march of malignant growth by damping down the cell metabolism with cold. A number of hopeless cases, in severe pain, were immersed in cold baths for periods as long as 7 days; the pain disappeared rapidly and the growth rate appeared to be retarded. McCravy (1940) applied local cold applicators to the treatment of hopeless growths of the bladder, certainly with the relief of pain.

Development

Allen (1938) of New York, however, deserves the credit for developing the [illegible] refrigeration method. The practice was established only after careful [illegible] were [illegible]

Observations

on the survival of tissues were [illegible]

kept cool; with the limb at room temperature the removal of the iquet, even after several hours, spelt almost certain sudden death for og. Allen further noted that after ischaemic refrigeration at 5° C. the ls were not thrombosed or damaged, the blood remained unclotted, and kin and other tissues continued fresh and intact. It seemed that the .edly reduced metabolism could offset the reduced circulation. These limbs were anaesthetic and the clinical application of this finding— utation under ice anaesthesia—was first applied by Crossman and his agues (1942) at the City Hospital in New York in 1941. *Clinical application*

anaesthesia was not quite a new idea. An Italian, Severino, in 1646, is to have used it for operations; Baron Larrey in his memoirs recounts in 1807 he was able to amputate painlessly, on the battlefield, where the temperatures were −19° C. An Englishman, James Arnott, in 1854 wrote a book on the use of cold as an anaesthetic agent, using an ice and salt mixture held in gauze or tulle, for operations such as the removal of local tumours He records that Velpeau and Nélaton at the Hotel Dieu, Paris, were incising and amputating fingers under ice anaesthesia, and he interestingly goes on to declare that "for amputation of the limb, suspension of the circulation would be necessary". A pupil of Paget, Nathaniel Ward, also describes how he helped Paget to remove, under salted ice anaesthesia, a large fatty tumour, 4 inches in length on the back. Erichsen used such icing to reduce the size of what was probably a naevoid tumour, before removing it About the same time, too, Mortimer Granville exhibited a small metal box to the Obstetrical Society, "as a means of relieving the pain attendant on parturition", the box was filled with a freezing mixture and was applied to the seat of the pain. Soon after this, general anaesthesia came into its own and the icing method was forgotten for nearly 100 years. It is to be observed that the present method is not a freezing of tissues but a mere numbing with cold.

3 TECHNIQUE OF REFRIGERATION

The original method of Crossman and his colleagues (1942) is eminently satisfactory. The limb with the tourniquet is embedded in finely chopped ice, and enclosed within rubber sheeting It is as well to have 100 pounds of ice ready in a suitable container. (This amount of ice is equivalent to 4 bucketsful.) The ice should be finely chopped, as otherwise air pockets form between the large chips and refrigeration is imperfect.

The patient, with a rubber ring under the buttocks, should be well propped up with pillows To counter overbalancing or sliding, it is as well to have pillows under both elbows, and a sandbag against the opposite foot. The head of the bed is raised [illegible] inches on blocks, to prevent the melted ice-water pooling in the bed. Two broad rubber sheets are spread beneath the affected limb (from which all dressings have been removed), and draped so that the bottom end is left open and the melting waters drain into a bucket (Fig. 219) A woollen blanket, well tucked in, protects and maintains the warmth of the opposite leg and of the scrotum. The ordinary routine of the patient is not disturbed and he is given his full usual diet and, if need be, insulin In women, a catheter in the bladder is usually advisable, for the bed-pan presents difficulties. Papaveretum, $\frac{1}{6}$ grain, or a barbiturate, may be used as *Position of patient*

Premedication premedication. Heavy sedation is to be avoided, for nearly all these patients are old and have learnt to adjust and to balance their fears.

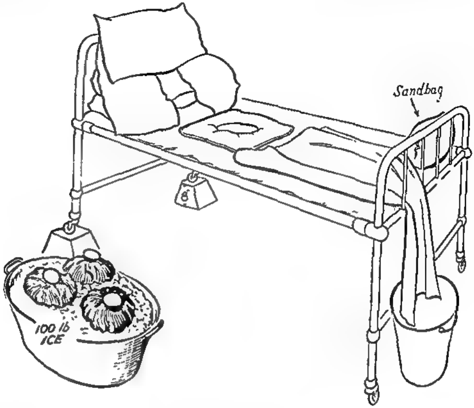

FIG. 219.—Refrigeration anaesthesia. The bed "set-up".

The amputation flaps are accurately marked out on the skin, with Bonney's blue, or a "ball-point" pen (Fig. 220).

Tourniquet In my opinion, a tourniquet should invariably be used with refrigeration, and its place, 3 inches above the election site, is inked in. Three rubber ice-bags—they must contain no salt—are applied to the tourniquet site and left

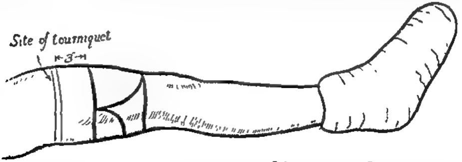

FIG. 220.—Preliminary marking out of the amputation flaps.

on for 20–30 minutes, to lessen the sensibility of the skin to the tourniquet

Application (Fig. 221). The correct application of the tourniquet is important; soft rubber pressure-tubing ($\frac{3}{8}$–$\frac{1}{2}$ inch), carefully chosen, is used and the rubber must be elastic. The thigh is encircled twice and the turns, if possible, are superimposed. Care is taken to avoid the pinching of a skin fold. The correct

observers have commented on the extraordinarily cheerful manner of the patients, their calm and joking attitude and their interest in the method. Careful readings of blood-pressure have indicated no fall.

The instruments will have been cooled and the saline solution for the hand-bowls is kept in flasks on ice. With the surgeon washed up, the patient is now

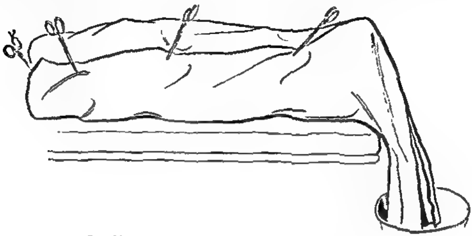

FIG. 223.—Rubber sheeting secured to enclose the limb.

wheeled into the theatre, still in his bed, his ears will have been plugged, but to cover the noise of sawing the bone, which is the only unpleasant feature of it all, the water taps may be turned on. The ice is rapidly parted from the leg and the patient lifted clear from the bed on to the operation table. The leg is dried with a sterile towel, and iodined, and the amputation proceeds. There is no need to hurry, for anaesthesia will be maintained for a full hour. Careful 5-minute readings have not shown a fall of blood-pressure during the operation.

4. THE AMPUTATION

Skin and fascia flaps are cut as one, and dissected off the muscles up to the bone mark level. With a large amputation knife, the muscles are next divided at the same level, and the bone is immediately transected without any attempt at stripping of the periosteum up or down, a muscle retractor is unnecessary. A theatre assistant now releases the tourniquet; the muscles, brick-red in appearance, bleed freely; the skin scarcely bleeds a drop. The deep red colour of the muscles, as Lewis (1941) pointed out, is due to the fact that at such low temperatures, blood will not part with its oxygen and the capillaries thus contain unreduced oxyhaemoglobin. There appears to be no spasm of the deep vessels from the cold, as might be imagined, and haemostasis may be troublesome. To assist haemostasis and to speed the operation, I often resort to the diathermy

Drainage

Through tenotomy knife stabs in the anterior flap, two small pieces of Carrel's rubber tubing are inserted and as blood has been found to stay fluid in these cases for many hours, a collection may be removed by aspirating these tubes every 4 hours. They have the further advantage of permitting the local injection of 3 millilitres of penicillin solution, 5,000 units per millilitre, into each tube, after the aspiration, and thus assist, at the same time, in

Aspiration of tubes

coping with the local sepsis problem. The rubber tubing emerges through the dressing and has attached to it the McKissock cannulae which permit the aspiration and injection to be undertaken under safe sterile conditions. The tubing, held by a stitch, is removed on the third or fourth day, as soon as the aspiration of blood ceases.

The cooling of the stump by ice-bags, as recommended by many authors, is to be avoided. The stitches are retained until the fourteenth day. In the meantime the patient is encouraged to get out of bed and to exercise the stump.

Devices for icing

Numerous devices have been suggested for facilitating the icing, such as special ice containers, thin rubber ice-bags, and "electrical refrigerating blankets"; perhaps the most convenient of all is the expedient (Hughes, 1947) of an upturned single limb cradle, as a trough for holding the rubber sheets. The actual use of ice is of some advantage: it is "fool proof", for owing to the air-spaces between the chips the temperature of the limb will not fall below 5° C., and freezing of the tissues is thus prevented. Kirz (1944) has pointed to what at first seemed a serious drawback to the use of ice; she described a case of gas gangrene following such amputation—*Clostridium welchii* was cultured from the ice. I have repeated the investigation and have been unable to confirm her findings. Hughes cultured 10 consecutive specimens of ice, "but in no case were pathogenic bacilli isolated, aerobically or anaerobically". Tobias (1946), however, regards such gas infection as a definite risk of the method; but, indeed, this is a well-known complication in amputations of the aged, and many surgical clinics give anti-gas gangrene serum as a routine.

Dangers of infection

5. DURATION OF ICING

The thick thigh, with the tucked-away sciatic nerve, takes some 2½ hours to be chilled, for the thinner leg or the upper extremity 1½ hours' immersion is sufficient; the finger, held in a glass of iced water, with a rubber band as a tourniquet, is completely anaesthetic in 15 minutes. Within limits, there is no particular advantage in hurrying the icing time. I have refrigerated a thigh for 5 hours with a tourniquet and subsequent primary healing of the stump; the literature contains frequent references to 6 hours, 10–12 hours, and even 54 hours (Allen, 1946), with unaffected subsequent skin healing.

6. THE TOURNIQUET

The use of a tourniquet may seem dangerous, for there is a belief that the atheromatous vessel-wall may be fractured. Actually, such vessels are well cushioned off, and from personal experience and a study of the literature, I feel that any such danger can be discounted. In the below-knee amputations there need be no hesitation in placing the tourniquet above the knee to ensure the more adequate control of the bleeding; the healing of the stump has not been affected. An attempt should not be made to exsanguinate the limb by using the Esmarch or other type of rubber bandage, as this might lead to squeezing of the infected tissues.

It is impossible to anaesthetize a normal limb by refrigeration without a tourniquet; that it is possible to do this in the ischaemic limb is not an argument for dispensing with the tourniquet.

7. EFFECTS OF COLD

(1) On infection

That cold arrests the growth of pathogenic organisms is a well-known observation, yet organisms may be kept alive for long periods at temperatures of 5–10° C. without being damaged or destroyed. Brooks and Duncan (1940) have shown, experimentally, that although cold may restrain the manifestations of infection, "after refrigeration is discontinued, the destructive effects of infection may be increased". Moreover, as Bruneau and Heinbecker (1944) show, such cooling inhibits the bacteriolytic qualities and growth-restricting action of living tissues, the effects becoming more marked as the refrigeration time is extended, and therefore cold should not be used as a form of therapy for the infected limb unless subsequent radical measures are contemplated.

Effects on living tissues

(2) On wound healing

Most figures indicate that healing is delayed after refrigeration; the advanced age characteristic of so many of these patients has been given as a reason, but we know that the fibroblast retains its powers until very late. The experimental work of Large and Heinbecker (1944) supplies unequivocal evidence to show that extreme cold does delay healing and that the delay is of significance in proportion to the duration of the cooling period.

Since cooling in the process of refrigeration anaesthesia is maintained for only a short period, such considerations of wound healing do not really arise. These facts, however, underline the inadvisability of post-operative cooling of the stump.

The electric hot cradle used to be advocated for treatment of the ischaemic limb, until, mainly from the teaching of Lewis, the hazard of accelerated cell metabolism came to be appreciated.

8. THERAPEUTIC APPLICATIONS

(1) Arteriosclerotic and diabetic gangrene

For most cases, safe general anaesthetic agents are available. There remains, however, a small group of cases in which refrigeration anaesthesia is a life-saving method. This group includes patients with advanced renal or cardiac disease; with severe bronchitis or senile phthisis; with uncontrolled diabetes mellitus; or a toxic patient, worn by nights of unrelenting pain.

Refrigeration plus the tourniquet will permit the intentional postponement of surgical measures in the gravely ill. The patient with spreading massive gangrene or extensive cellulitis of the leg may improve in most remarkable fashion in 24–48 hours with the arrest of toxic absorption. Refrigeration gives time for the administration of drugs and other resuscitative measures. "Physiological amputation to control uncontrollable sepsis" is indeed an apt description of the method. There are occasions, too, when the obstinate aging patient will refuse amputation, only to yield too late—the tourniquet plus refrigeration will permit of the delay required for persuasion, or the necessary legal sanction, or indeed the obtaining of a skilled anaesthetist for the final anaesthetic procedures.

(2) In trauma

For the hopelessly mutilated limb, when amputation is inevitable, and when the patient's general condition is too grave for immediate operation, tourniquet refrigeration may prove life-saving; it will permit resuscitative measures and the postponement of operation to a more propitious time. Mock and Tannehill (1944) and McElvenny (1941) have used it in this fashion. But it is to be stressed that the tourniquet must not be removed after refrigeration to test limb viability—absorption from dead or dying muscle may spell immediate death.

9. CONCLUSION

Refrigeration anaesthesia is painless, shockless and well tolerated by the most aged of patients. It may be the safest of all unsafe methods, particularly when skilled anaesthetists are not available. Cold is a deleterious agent and is not suitable as a form of therapy, particularly in the ischaemic limb; but it may be used, with the addition of a tourniquet, as a form of preparation prior to surgical intervention.

REFERENCES

Allen, F M (1938) *Surg. Gynec Obstet.*, 67, 746.
— (1946) *Clinics*, 4, 1642.
Brooks, B., and Duncan, G. W. (1940) *Ann. Surg*, 112, 130.
Bruneau, J., and Heinbecker, P (1944) *Ann. Surg*, 120, 716.
Crossman, L. W, Ruggiero, W. F., Hurley, V., and Allen, F. M. (1942) *Arch. Surg., Chicago*, 44, 139.
Fay, T (1940). *N.Y. St. J. Med.*, 40, 1351
Hughes, E S. R. (1947) *Brit. med. J.*, 1, 761
Kirz, E. (1944) *Brit. med J*, 2, 662
Large, A., and Heinbecker, P (1944). *Ann. Surg*, 120, 727, 742
Lewis, T. (1941) *Brit med J*, 2, 795.
McCravy, A (1940). *N.Y St J Med*, 40, 1435
McElvenny, R. T. (1941) *Surg Gynec. Obstet*, 73, 263.
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REFERENCES

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— (1946). *Clinics*, 4, 1642.
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Fay, T. (1940) *N.Y St. J Med*, 40, 1351.
Hughes, E. S R. (1947) *Brit. med. J.*, 1, 761
Kirz, E. (1944) *Brit med. J.*, 2, 662.
Large, A , and Heinbecker, P. (1944) *Ann. Surg*, 120, 727, 742
Lewis, T. (1941) *Brit. med. J*, 2, 795
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RESUSCITATION

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1. INTRODUCTION

295.] Resuscitation is usually discussed in association with "wound shock". Here, we confine ourselves to describing (1) the signs and symptoms displayed by injured patients that we have found of most value in assessing the gravity of their state and for indicating treatment, and (2) the details of the treatment that in our experience has proved most successful for maintaining or restoring the circulation in patients injured on the roads, at work and in war. The following account is based on experience gained during World War II. It deals mainly with limb injuries—the most common and best-studied aspect of all. It excludes injury produced by burning and by prolonged compression (the so-called "crush-syndrome").

2. LIMB INJURIES

Shock produced by haemorrhage

The chief factor producing the circulatory disturbance after injury, commonly called "wound shock", *is blood loss by haemorrhage; replacement of blood* loss by early and adequate transfusion suffices for recovery in the great majority of cases, even those with very large injuries. The assessment and treatment of blood loss, therefore, are of prime importance. Other possible causative factors and their treatment are as yet insufficiently elucidated to warrant discussion here. If transfusion fails we are at a loss for a remedy.

(1) Before operation

Importance of immediate examination

Special emphasis is laid on diagnosis and treatment as soon as possible after admission to hospital, for if blood loss is then correctly assessed and the proper treatment carried out, many of the difficulties occurring at, and after, operation will be avoided. No matter how trivial or serious the injury may seem at first sight, the patient should be undressed and examined. Nothing is to be gained, and much may be lost, by delaying examination. It is only in the most serious cases that thorough examination of the wounds and

circulatory state should be delayed, because of the urgent need to arrest haemorrhage or to give immediate transfusion.

(a) Assessment of blood loss

The most direct and accurate means of assessing blood loss is the measurement of blood volume, but the methods so far available are not sufficiently simple or rapid for routine clinical use. In the great majority of cases, however, blood loss can be estimated by other means with sufficient accuracy to guide treatment clearly.

(i) *Size of wound.*—The most valuable index of blood loss, obtainable at the bedside, is the size of the wound. This is assessed on an estimate of the volume of tissue damaged, relative to the total volume of the limbs. Though often the estimate can be made properly only at operation or necropsy, usually, if the wounds are carefully examined, a sufficiently good estimate can be made when the patient is first seen The patient's hand is taken as the unit of volume in assessing the volume of tissue damaged The hand may be used open to assess the damage of superficial wounds, or closed to estimate the volume of a bruised or pulped segment of limb. In a man of average size, the volume of the hand, open or closed, is just under 500 cubic centimetres The foot, knee, forearm and upper arm are approximately equal in volume (the foot and knee each rather less, and the upper arm rather more, than the forearm), and each is roughly equal to from 2 to 3 times the volume of the hand Leg volume is from 4 to 5 times, and thigh volume from 10 to 12 times, that of the hand. Wounds are grouped into four categories (1) Small wounds: damage of less than 1 hand in volume. (2) Moderate wounds: damage of 1 hand or more but less than 3 hands (3) Large wounds. damage of 3 hands or more but less than 5 hands. (4) Very large wounds damage of 5 hands and over.

Unit of volume

To avoid errors in the estimation of their size, the wounds must be carefully examined Long, deep incised wounds and wide superficial wounds may, by their gaping, suggest much more extensive tissue damage than is actually present Small wounds indicate that little blood has been lost—no more than 20 per cent of the total, and probably only from 5 to 10 per cent, large wounds indicate a loss of the order of 40 per cent, and very large wounds a loss of the order of 50 per cent of the total blood. Moderate wounds offer a less clear indication; blood loss may have been great or small, though usually the amount varies between 20 and 40 per cent

(ii) *Systolic blood-pressure*.—The second valuable index of blood loss, obtainable at the bedside, is the level of the systolic blood-pressure, for this shows how far blood loss has reduced the blood volume In exemplification of this: (1) a blood-pressure of 100 millimetres of mercury or more indicates that the blood volume is at least 70 per cent of normal; (2) a blood-pressure of over 140 millimetres that the blood volume is probably at least 80 per cent of normal, and (3) a blood-pressure of less than 100 millimetres of mercury that the blood volume is below 70 per cent of normal

Interpretation of blood loss and blood volume

These two indices, size of wound and blood-pressure, usually leave little doubt about the order of blood loss and blood volume. The evidence provided by each is usually concordant. For example: (1) small and moderate wounds are usually associated with a blood-pressure of 100 millimetres or more; the combination is reasonably certain evidence that blood loss has been

insufficient to reduce the blood volume below 70 per cent of normal. (2) Large wounds are usually, and very large wounds almost always, associated with a blood-pressure of less than 100 millimetres, and the combination indicates a blood volume below 70 per cent of normal; the larger the wound the lower is the blood volume likely to be. Sometimes, however, the evidence provided by these indices seems discordant. For example: (*1*) large or very large wounds may be associated with a blood-pressure of 100 millimetres or more. The interpretation is that less blood has been lost than is usual from such wounds and that, though the blood volume remains above 70 per cent of normal, it is probably not far above this figure. (2) Small wounds may be associated with a low blood-pressure (under 100 millimetres). The interpretation usually is that blood-pressure has been lowered by nervous factors (vaso-vagal attack); less usually that much blood has been lost.

Although wound size and blood-pressure provide the main indices in the assessment of blood loss, additional evidence may be gleaned from subsidiary features.

Subsidiary features as indications

Indications of blood loss may be available in the amount of blood shed on to the dressings and clothes, or information may be obtained from the patient himself, his attendants, and witnesses of the injury. Although positive information of this nature may be of value, its absence cannot be taken as evidence against blood loss

Further indications of the level of blood volume are provided by the pulse rate, *the facial colour and the temperature of the extremities. None of these* is of much value by itself, but in combination with each other and with the blood-pressure they provide circulatory patterns of diagnostic importance. Thus, *the pattern of low blood-pressure, with a fast pulse rate (100 or over),* and a pale face and cold extremities, is a clear indication of blood loss sufficient to reduce the blood volume below the critical level of 70 per cent of normal, even though the wounds are small. The pattern of very low blood-pressure (under 70 millimetres of mercury), impalpable pulses, a very rapid heart rate and marked pallor, often with the added symptoms of great restlessness and dyspnoea, clearly indicates great blood loss and a blood volume reduced to the point of death—that is, 50 per cent or less of normal.

Possible nervous origin for circulatory depression

On the other hand, the combination of low blood-pressure, pallor, cold extremities and a slow pulse rate (vaso-vagal syndrome) indicates a circulatory depression brought about by sensory and emotional stimuli rather than by blood loss, even when there are sighing respirations, sweating, nausea and vomiting in addition. The finding of this combination, however, does not exclude the possibility of much blood loss Such loss is unlikely if the wounds are small, speedy recovery of blood-pressure, when the patient is placed in the supine and head-down position, speaks against much blood loss and in favour of a nervous origin for the depression.

Again, in patients with a normal blood-pressure, the associated signs may help in determining whether the blood volume is nearer the normal than the critical level. Thus, the pattern of normal blood-pressure, with a good facial colour, a normal pulse rate and warm extremities, very probably indicates that the blood volume is normal or nearly so; the pattern of normal blood-

In interpreting the circulatory patterns to be observed in patients with limb injuries, three general points should be borne in mind. The first is that the sooner after injury the patient is seen, the more likely are nervous factors to disturb the circulation and to complicate the assessment of blood loss. Secondly, in dealing with older patients, it should be remembered not only that the pulse rate is, on the whole, slower than it is in the younger patients, but that they may suffer from a pre-existing hypertension. In older patients also, it is possible, though this is as yet undetermined, that the critical level of blood volume for a fall of blood-pressure may be nearer 80 than 70 per cent of normal. Thirdly, these rules apply in their entirety only to patients not previously transfused. The modifications necessitated by prior transfusion are mentioned below (*see* p. 404).

Possible pre-existent hypertension

These rules provide a sound basis for prognosis and for indicating treatment. Thus, for example, at one extreme, patients with small wounds and the normal circulatory pattern have blood volumes not far below normal, they will maintain their circulation without transfusion before, during and after operation. At the other extreme, patients with very large wounds and marked circulatory failure have blood volumes well below the critical level of 70 per cent of normal; they are in a dangerous state; unless they are at once adequately transfused, death may soon supervene; few will survive operation for long, and even the survivors are likely to have a stormy course towards recovery. Between these two extremes are patients with moderate or large wounds, whose circulations are precariously maintained until the time of operation, but who, unless adequately transfused beforehand, are then likely to develop circulatory failure.

Indications for treatment

(*b*) *Transfusion*

(i) *Patients to be transfused.*—Those patients do best whose blood volume is maintained well above the critical level of 70 per cent of normal before, during and after operation All patients, therefore, in whom the examination of the wounds and circulatory state leads to the conclusion that the blood volume is below, or not far above, this level should be transfused. If in doubt, transfuse.

(ii) *The fluid to be transfused.*—Since loss of whole blood is the chief factor causing circulatory disturbance, blood is the fluid of choice for transfusion. Nevertheless, the blood volume can be raised and the blood-pressure restored by plasma or serum alone, even after gross blood loss In such cases, however, the patient remains seriously deficient in red cells How far these may be depleted without interfering with recovery is unknown; it is desirable that haemoglobin should remain above 60 per cent and that in any case it should not be allowed to fall below 50 per cent for more than a short time.

(iii) *When to transfuse.*—Experience shows that to delay transfusion is bad practice, and emphasizes two points (1) that in any patient having a limb or soft-tissue injury, with a blood-pressure under 100 millimetres, unless there is prompt recovery in the head-down position, it is unwise to delay transfusion; (2) in cases in which there is a marked degree of circulatory collapse (blood-pressure under 70 and usually a very rapid pulse rate, together with great pallor, cold extremities and often great restlessness and dyspnoea) there must be no delay in beginning transfusion if life is to be saved.

(iv) *Rate of transfusion.*—Slow transfusion not only delays recovery but, in patients with marked circulatory failure, may result in early death. In such cases, therefore, transfusion must be rapid, at the rate of a bottle (approximately 1 pint) in from 5 to 15 minutes—that is, as fast as the blood or other fluid will enter the vein under gravity or air pressure, or through a two-way syringe. When, in spite of pressure, the rate of transfusion is slowed by venous constriction, it can be speeded by applying a hot-water bottle over the site of transfusion. To give sufficient blood quickly enough it may be necessary to transfuse into two sites. Transfusion is usually faster by way of the veins of the arm than by those of the leg; the jugular veins may, on occasion, offer a better site than either. It is not usually necessary to cut down on a vein; a needle can almost always be inserted by the expert, but there must be no bungling and no delay in cutting down if this proves necessary.

Veins of choice

When the patient has responded well to transfusion, its rate should be slowed, to a bottle in half an hour or longer. In less serious cases, and when transfusion is given prophylactically, the slower rate is sufficient, provided that the patient receives an adequate amount of blood before being submitted to operation

Risk of rigors and renewed haemorrhage

Rapid transfusion is often feared because of the possibilities of producing rigors, and a renewal of haemorrhage. Rigors are more likely to be provoked and to be more severe, with rapid than with slow transfusion, but, provided the patient is given blood properly matched and of good quality, severe transfusion reactions, though alarming, do not cause ill effects. The chief danger of a transfusion reaction, in gravely ill patients, is that it may cause such a degree of venous constriction that it is difficult to pump in blood fast enough or to replace transfusion needles and cannulae, which are liable to be displaced by the restless patient. Renewed bleeding is not avoided by slower transfusion. In seriously ill patients the dangers of delayed or slow transfusion far outweigh those arising from the renewal of bleeding. The answer to the danger of renewed bleeding is to bear the possibility in mind and to have the means of arresting it at hand. Another danger arises when, to increase the rate of transfusion, the air pressure is raised within the bottle. Then there is the possibility of air being forced into the vein as the bottle empties. If, however, the patient is carefully attended to, and the possibility borne in mind, the likelihood of this accident occurring is small.

Dangers of air embolism

(v) *Amount to be transfused*—This is determined by the consideration of a number of factors

(1) The level of the blood volume before transfusion, as assessed by an examination of the wounds and of the circulatory state.

(2) The level to which it is desired to raise the blood volume.

Whether transfusion to restore the blood volume to normal is advisable or not is unknown, for it has not been followed in practice. Moreover, since patients can pass through an operation safely with a blood volume below normal (about 80 per cent of normal) and since there is a risk, though it is small, attached to the transfusion of stored blood and its products, it seems advisable to transfuse as little as is compatible with safety at operation. Allowing a margin for renewed bleeding at, and for continued oozing after, operation, 90 per cent of normal seems to be a safe level to aim at for the beginning of operation

(3) The amount by which the transfused fluids increase the blood volume.

Plasma and blood are supplied in pint bottles containing nominally 540 cubic centimetres. Because of the added diluents, these transfusion fluids may be expected to increase the blood volume, not by 540 cubic centimetres but by less; a bottle of plasma would effect an increase of about 300 cubic centimetres and one of blood by about 430 cubic centimetres or by approximately 5 and 8 per cent respectively of the blood volume of the average normal male (5·5 litres). A bottle of serum containing about 500 cubic centimetres, provided its protein content is adequate, may be expected to increase the blood volume by this amount, or by approximately 9 per cent of the average normal blood volume. These percentages require adjustment to suit the variations in normal volume, as determined by age, sex and size.

Adjustments according to age, sex and size

(4) The effect of transfusion on the circulation.

It is commonly thought that restoration of the blood-pressure to normal indicates that transfusion has been adequate, the implication being that the blood volume has also been restored to normal. But, restoration of the blood-pressure to normal, indicates only that the blood volume has been raised to the critical level of 70 per cent of normal or above; how far above is uncertain. If, however, transfusion not only restores the blood-pressure to normal but also restores a normal pulse rate, a good facial colour and warmth to the extremities, then it is a fair inference that the blood volume has been raised to nearly normal. Pre-operative transfusion, particularly when rapid, seldom results in the restoration of this, the normal circulatory pattern. Often, because of the pharmacological properties of the transfused fluids, tachycardia, or both tachycardia and vasoconstriction (as shown by coldness and pallor) persist, though the blood volume is raised to nearly normal. Moreover, a severe transfusion reaction may temporarily raise the blood-pressure to normal or above, although the blood volume remains below the critical level.

Possible persistence of tachycardia and vaso-constriction

Consideration, therefore, of pulse rate, facial colour, and temperature of the extremities does not, in general, help to determine whether or not transfusion has been adequate. In the absence of rigors, the point at which the blood-pressure is restored to normal may be taken to indicate that the blood volume has then been raised to approximately the critical level of 70 per cent of normal. Transfusion should be continued beyond this point with an amount equivalent to 20 per cent of the predicted normal blood volume, so that the blood volume may be raised to 90 per cent of normal, a safe level before operation.

It should be noted that a patient transfused before being seen by the surgeon may show pallor, cold extremities and a very rapid pulse rate of 140 or more. If it is not recognized that this state may have been caused by the previous transfusion, blood loss may be over-estimated and the patient may be thought to be in a more dangerous state than he actually is.

These data, combined, provide a useful indication of the amount of transfusion to be given. Thus, for example, a man of average size, assessed from an examination of his wounds and his circulatory state to have a blood volume of about 70 per cent of normal, should be given, before operation, a transfusion equivalent in volume to 20 per cent of his normal blood volume; that is, from 2 to 3 bottles of blood or serum or 4 bottles of plasma. If, on the other

hand, he was assessed to have a blood volume of 50 per cent of normal, these amounts would be required to restore the blood volume to the critical level and the blood-pressure to 100 millimetres of mercury or above; he would then require further transfusion of the same volume, in order to raise the blood volume to 90 per cent of normal. For the great majority of patients requiring transfusion, the amounts indicated by these data are satisfactory. In rare cases, however, particularly when the patient has very large wounds, larger amounts may be required; why is uncertain, but perhaps it is because of continued blood loss which may not be visible as external haemorrhage.

Internal haemorrhage

(c) *Other therapeutic measures*

These measures are important adjuncts to transfusion.

(i) *Arrest of haemorrhage.*—It is important to prevent further blood loss, not only initially but also later. In the interval between admission and operation, watch must be kept for continued or renewed haemorrhage, whether or not transfusion is given, and the means of stanching bleeding must be at hand. In a patient with a blood volume near the critical level, even a small further blood loss may be sufficient to reduce the blood volume below this level and so precipitate a fall of blood-pressure.

(ii) *The head-down position.*—The adoption of this position is a valuable measure in patients with hypotension initially and in whom the blood-pressure later falls steeply. Raising the foot of the bed by about 12 inches will usually result in raising a low blood-pressure by from 5 to 10 millimetres of mercury. In instances of the vaso-vagal reaction this procedure may suffice to secure rapid restoration of the blood-pressure, but the position is uncomfortable and should not be maintained longer than is necessary. A renewed and sustained fall of blood-pressure, when the patient is returned to the horizontal position, is an indication of under-transfusion.

Under-transfusion

(iii) *Morphine.*—This should be given to relieve pain and apprehension. In the presence of gross vasoconstriction, morphine, ¼ grain, given subcutaneously, may not be absorbed rapidly and further injections may result in over-morphination when the vessels relax later. Intravenous injection of morphine, ¼ grain, may be required for the speedy relief of severe pain.

(iv) *Oxygen, Coramine or vasoconstrictors*.—The administration of oxygen, of Coramine or of vasoconstrictor drugs such as adrenaline has not been found of value in these cases.

(v) *Application of warmth*.—Warmth should be applied when the patient is cold, and the temperature regulated to his comfort. Over-heating increases the patient's discomfort and restlessness, and may lead to a fall of blood-pressure. Loss of fluid by sweating must be avoided.

(vi) *Rest*.—Rest is important. Because of the possibility of originating depressor reflexes, the injured parts must be handled with the greatest care. Clothes should be cut off badly injured patients. Once in bed and examined, the patient should be helped to rest, and his wants attended to and anticipated.

(vii) *Fluids by mouth*.—It is uncertain whether or not unlimited fluids should be given by mouth because of the danger of provoking vomiting at operation. The authors prefer to give only repeated sips of water, even to the avidly thirsty.

[V]omiting operation

(d) When to operate

In cases of small or moderate wounds without much blood loss there is no urgency for early operation, but to prevent the development of infection it is advisable to operate within 6 hours of injury. In other cases, operation should be undertaken as soon as possible after the circulation is restored. If transfusion is properly carried out, most patients should be well resuscitated within an hour or two of admission. In the case of large and very large wounds, it may be necessary to operate although the blood-pressure is not restored, either because of renewed bleeding or because of a failure to respond properly to transfusion. Nothing is to be gained, and much may be lost, by delaying operation in such circumstances. With large and very large injuries, there is a period of a few hours after injury when most patients can *be much improved by transfusion, and operation within that period offers the best chance of recovery, even though the blood-pressure is low.* The best results are obtained by early operation after rapid and adequate transfusion.

(2) At operation

Provided that blood loss has been adequately replaced beforehand, little difficulty should be experienced at operation. Adequately transfused patients, even those with very large injuries, can pass through a long and difficult operation without developing circulatory failure either then or later. The nearer the blood volume is to the critical level, the more liable is the circulation to fail during operation.

Because of the difficulties that may arise and the danger of renewed bleeding, transfusion should be continued slowly as a precautionary measure, so that *it may be speeded up if required. It is simpler and safer to do this than to* begin or restart transfusion at operation *Continuous transfusion, as precaution*

Once again the best guide to the patient's state at operation is the level of the systolic blood-pressure. A fall of blood-pressure, due to haemorrhage, requires rapid transfusion A steep fall of blood-pressure following manipulation indicates that transfusion should be speeded up; operation should be suspended until the blood-pressure rises. The head-down position may aid in the recovery from a fall of blood-pressure. It is important to note the course of the blood-pressure after the withdrawal of the anaesthetic at the end of the operation, for then it may fall rapidly to dangerous levels. If this happens, rapid transfusion is required.

It is advisable to keep the total length of operation within 1 hour, that is from the beginning of the administration of the anaesthetic to the end of bandaging. In cases of extensive and bilateral injuries, two surgeons should operate A short operation, however, with rough surgery and inadequate haemostasis, may do more harm than a much longer one in which the injured parts are handled as gently as possible and haemorrhage is reduced to the minimum.

Evidence is lacking on which to base a preference for one anaesthetic over another, but whichever anaesthetic is used it is clear that skilful administration is of great importance. *Choice of anaesthetic*

(3) After operation

The early post-operative period, particularly for those patients with large or very large wounds which have bled severely, *is a period of danger,* and

patients require as careful attention and as skilful handling then as they do in the periods before and during operation. All patients with very large wounds need watching with the greatest care for the first 12 hours after operation, since life often seems to hang by a thread and to depend upon a damaged or unstable circulatory control.

Circulatory failure

The chief illness, and the dangerous one, in this period is again circulatory failure, which either continues from operation or develops shortly after. It is seen mainly in those patients who have bled extensively before, and sometimes during, operation, particularly in those with large and very large wounds and in whom transfusion has been inadequate; it may be precipitated by the continued oozing of blood from open wounds. It is usually associated with a blood volume in the region of 70 per cent of the predicted normal; in general, patients with a post-operative blood volume of about 80 per cent of normal or more do not develop circulatory failure. The treatment is further transfusion.

In this period the best guide to blood volume is the blood-pressure, though its indications are less certain than in the initial stage. Facial colour, pulse rate and the temperature of the extremities give but little help in determining the level of the blood volume.

A normal blood-pressure after operation usually indicates a blood volume not below the critical level of 70 per cent of normal. In patients with a normal blood-pressure the course is usually uneventful and further transfusion is not required. Nevertheless, a normal blood-pressure at the end of operation occasionally gives a false impression of the circulatory state and, unless he is watched, the patient may develop, unnoticed, a dangerous hypotension.

A persistently low blood-pressure (under 100 millimetres of mercury) usually indicates a blood volume below 70 per cent of normal. On occasion, particularly in patients with very large wounds, a low blood-pressure is associated with a blood volume of 80 per cent of normal or more; such patients show evidence of good blood flow through the extremities; the face is well coloured or pale.

Indication for further transfusion

A persistently low blood-pressure indicates the need for further transfusion, which should be continued until the blood-pressure is restored. Except when the blood-pressure is very low, rapid transfusion is not required; a rate of 1 bottle in from ½ to 1 hour suffices.

In the majority of cases displaying hypotension, little difficulty arises and the blood-pressure should be restored within an hour or two after operation, but, in patients with very large wounds and in whom a low blood-pressure persists, doubt may arise whether or not to continue transfusion. In such patients, it is very important that the blood volume should be raised well above 70 per cent of normal, but they may have already been given so much transfusion that a further amount is feared as excessive. For the proper control of their treatment, therefore, measurement of the blood volume is essential. When there is doubt and if the blood volume cannot be measured, transfusion should be pursued, for under-transfusion, rather than over-transfusion, is to be feared. Sufficient transfusion, from the time of admission until after operation, in patients with very large injuries may mean transfusion of 12 or more bottles of blood, plasma or serum.

After operation, further transfusion may be required later to correct a

secondary anaemia. For this, fresh, rather than stored, blood is preferred. Difficulty may be experienced in finding a blood that matches satisfactorily with that of the patient. Particularly in cases with large and very large wounds, watch must be kept on the fluid intake and output, and for the development of complications, especially renal disturbance, fat embolism and wound infection. Provided that transfusion has been properly carried out, the flow of urine should be re-established within 24 hours of operation. *Correction of secondary anaemia*

3. ABDOMINAL INJURIES

Abdominal injuries have been studied less than have those of the limbs, but in them, as in limb injuries, blood loss by haemorrhage is the chief factor determining the circulatory state in the early stages, and much depends upon its proper treatment.

In the initial stages, therefore, the assessment of blood loss by haemorrhage is of prime importance. For this purpose, reliance has to be placed chiefly on the circulatory state, for, in these cases, the visible injuries provide little or no help in assessing blood loss; this is largely concealed until operation. In general, however, blood loss is not gross, being usually no more than 30 per cent of the total blood and often considerably less. The rules for the interpretation of the circulatory state, derived from the study of limb injuries, apply also to abdominal injuries, particularly to those seen within 8 hours of injury.

When the patient is seen later than about 8 hours after injury, the possibility of infection has to be borne in mind. Infection, on the one hand, may reduce the blood volume by causing plasma loss; on the other hand, by poisoning circulatory control, it may lead to hypotension, although the blood volume remains well above the critical level or even is normal. Gross plasma loss may be recognized by finding haemoglobin or haematocrit values above those normal for venous blood. *Development of infection*

Because of the lack of the valuable aid from assessment of wound size available in limb injuries, and because of the possibility of hidden infection, the assessment of blood loss is less reliable in abdominal than in limb injuries. Nevertheless, the evidence derived from examination of the circulatory state usually provides a sufficient basis for determining treatment before operation. In difficult cases, measurement of the blood volume is of great value.

Abdominal cases, like limb cases, do best at, and soon after, operation when the blood volume is maintained well above the critical level; 90 per cent of normal again seems a safe level for the blood volume at the beginning of operation, and therefore the same rules for transfusion before operation apply to them.

When the patient is seen early, since loss of whole blood is the factor reducing the blood volume, blood is the fluid of choice for transfusion. If there has been some delay during which fluid may have been lost from the blood, transfusion of plasma alone or of blood and plasma seems preferable, since continued fluid loss may lead to a considerable rise of the red-cell content of the blood, thus increasing the difficulties of the circulation. The decision to transfuse, however, should be made after studying the changes in the blood (haemoglobin or haematocrit values and plasma proteins). Experience

is too limited to permit the statement of more precise rules. It is not known how to restore circulation in those unusual cases in which transfusion fails to do so, whether because of infection or for some other reason.

Operation Early operation is always urgent and should be undertaken as soon as transfusion is judged adequate to replace blood loss, whether or not the blood-pressure has been restored.

At operation, transfusion should be continued slowly so that it may be speeded up as required; the need for this is judged on the same grounds as in limb injuries. Skilful administration of the anaesthetic is of the greatest importance.

Every patient requires watching with the greatest care for the first 24 hours after operation, further transfusion may then be required. In assessing the need for this, the level of the blood-pressure is again the best clinical guide; measurement of the blood volume gives a clear indication of this.

4. HEAD AND CHEST INJURIES

Such injuries have not been specially studied from this point of view. It is probable, however, that in them, also, blood loss by haemorrhage is an important, if not the chief, factor determining the circulatory state. It is not yet known how, if at all, injury to the brain or lungs may influence circulation and render necessary modifications of the rules given above for the assessment and treatment of blood loss.

[References to other titles are given under Resuscitation in the Index Volume The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol 10, p 596]

RETINA

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1. INTRODUCTION

296.] The surgery of the retina is practically confined to the treatment of simple detachment of the retina, and glioma of the retina. In this article, displacement of the retina caused by a primary tumour of the choroid, usually [redacted] malignant melanoma, [redacted] not considered, though reference will be made to the differential diagnosis of the two conditions.

2 SIMPLE DETACHMENT OF THE RETINA

(1) Embryology

The retina is derived from the two primitive layers of the optic cup which is formed by invagination of the optic vesicle, an outgrowth of the forebrain. The outer layer forms the future pigment-cell layer of the retina, and the inner layer forms the remaining neural and neuroglial elements of the retina.

A simple detachment of the retina is a reproduction of this embryonic state with the line of separation occurring within the substance of the retina and leaving the outermost pigment-cell layer attached to the choroid coat. The space between the layers becomes filled with fluid probably derived from the vitreous at the onset of the condition.

(2) Pathology

Ora serrata

Most sections of the retina after the age of 30 years show cystic degenerative changes at the ora serrata. These may be related to local deficient nutrition for this is the relatively bloodless area of the retina. It is possible that this region of the retina is largely nourished from the choroid. An anterior choroido-retinitis, perhaps partly degenerative and partly chronic inflammatory, is constantly present in cases of retinal detachment.

Ciliary epithelium

The sections of the retina in detachment also show dissemination of pigment through its substance and they often display a reduction in thickness to one-third of the normal In these cases also there may be proliferation of the ciliary epithelium. This may proliferate backward causing a fine pre-retinal membrane. It is quite possible that contraction of such a membrane may be a factor in the production of retinal tears.

Examination of vitreous

The vitreous body becomes involved secondarily to the changes in the retina and choroid, and becomes attached to a varying degree to the retina Involutionary changes in the vitreous must also be mentioned. It is possible by means of a Koeppé contact lens, a slit-lamp and an offset corneal microscope to examine the posterior part of the vitreous. In many cases with detachment of the retina this examination shows an interval filled with clear fluid between the posterior limit of the vitreous and the retina This condition of vitreous separation from the retina occurs in upward of 50 per cent of cases of simple detachment of the retina The process of shrinkage of the vitreous towards the lens may be interfered with by its fixation at various points to the retina near the ora serrata. At these points of union, tearing of the retina may occur, so starting the chain of events which leads to simple detachment. The contact between the vitreous and the choroid through a tear in the retina causes an inflammatory response of the nature of a foreign body reaction. This reaction in some cases serves to limit the spread of a detachment binding together the layers at its margin Further evidence of this reaction is seen in the change which takes place in the fluid separating the layers. This fluid at first is clear and free from albumin, but in the course of time, doubtless from choroidal exudation, the fluid becomes yellowish and albumin appears. Later, the retina and the choroid become atrophic if the detachment persists.

Tearing of retina

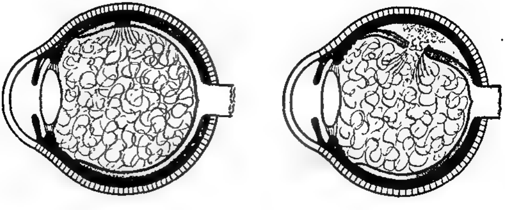
(3) Aetiology and mechanism of production of detachment of retina

Age incidence

A simple detachment of the retina is rarely congenital, though cases may occur in the first year of life At this age, and during childhood, detachment of the retina is generally due to active exudation from the choroid, and in some cases it may be associated with tuberculosis. The most common age is the fifth decade and 60 per cent of cases occur in myopic eyes, but the maximum frequency in myopia alone is in the third decade. The tendency to detachment is increased in the higher degrees of myopia. One-fifth of the number of cases gives a history of injury which may be from a blow on the head or direct injury to the eye, either a contusion or a perforation. The effect of such injuries may be to cause tearing of a retina weakened by old focal inflammation.

Retinal layers

There is a potential space between the two primitive layers of the retina which are attached normally at the ora serrata and the optic disc only. They are kept in apposition by the intra-ocular pressure and in conditions of low



(a) (b)

Fig. 1.—(a) Diagram of eye showing adhesion of vitreous to retina and choroid; (b) tearing of retina at point of adhesion following the transmission of an impulse across the vitreous by a blow upon the eye.

Fig. 2.—Left eye Shallow simple detachment of retina in upper temporal quadrant, showing a retinal tear.

PLATE III

tension immediately following, for example, operations for the removal of cataract, detachment of the retina or of the choroid may occur. Consequently, these retinal layers are fairly easily separated and where traction upon the retina occurs at a point of vitreous detachment, the two layers come apart. A blow upon an eye in which the vitreous is suspended by an adhesion to the retina above, causes a wave-impulse through the vitreous, traction at the point of adhesion and tearing of the inner layer of the retina (Plate III, Fig. 1). *Easy separation*

The character and extent of the vitreous adhesion probably determine the shape of the tear. Tears have characteristic shapes: horseshoe, arrow-head or crescent. They may be irregular and large, being many disc diameters in length; they are often round and multiple; a special type is the disinsertion of the ora serrata. This type is produced by a local retraction of the anterior border of the retina. Following the production of a tear, fluid from the vitreous passes through and divides the retina into its components. When the tear is above, the fluid tends to track downward under the force of gravity. In a variable time, from a few hours to a few months, the whole retina may become detached. *Tear shapes*

(4) Symptoms

Most people complain of a shadow which passes across the field of vision but many refer only to the onset of blurred vision. Some speak of black spots which are caused by small haemorrhages into the vitreous, produced by tearing of the retina. Occasionally, flashes of light (photopsia) localized to one point of the field of vision, indicate mechanical stimulation of the retina at the point of origin of a detachment.

(5) Examination

In no other branch of ophthalmic surgery does the result so much depend upon the pre-operative examination. Careful fundus study of both eyes should be made in a suspected case and a diagram of the features of both fundi should be prepared. Drawing a fundus ensures careful examination. In the eye without retinal detachment, any foci of pigmentary change or atrophy should be noted. It is essential that the examination be conducted under maximal mydriasis and a subconjunctival injection of atropine and adrenaline is given for this purpose. Both the direct method of ophthalmoscopy and the indirect method should be used. The prismatic effect of the lens used in the latter method allows a view of the retina a little farther forward than by the direct method. *Diagram of fundi* *Mydriasis*

More important than the method, however, is the necessity to have very good illumination of the fundus. The detached area has a translucent, grey, raised appearance; its surface may be thrown into folds or appear to be ribbed like sand on the seashore. Sometimes there is a voluminous ballooning or, alternatively, the detachment may be so shallow as to be visible only because of lack of definition of the tigroid pattern of the choroid. The retinal vessels on the surface of the detachment follow its contours. *Illumination*

Tears

Examination is largely devoted to the discovery of the tears. These often can be found by following the main vessels systematically to the periphery. They

are sharply defined and bright red in colour in marked contrast to the greyish red area of the surrounding detachment. Tears are quite common in the upper half and most frequent of all in the upper temporal quadrant (Plate III, Fig. 2). They are not always at the site of the greatest detachment. Their discovery demands immediate action; they should be included in the diagram previously mentioned and their meridian marked on the eyeball, because frequently with the change in the contours of a detachment after rest, tears may become more difficult to find. In this search for tears it is quite essential to examine the patient in a sitting position. It has been noted that in old detachments, tears become increasingly difficult to see; this may be due to their obliteration by the development of pre-retinal sheets of tissue.

Site

Position for examination

As the retina settles back, tears may become more peripheral and their colour-contrast less obvious. In addition, this essential preliminary examination should include the testing of vision The chief object of this is to form a judgement on the state of the macula. As a detachment approaches this region, metamorphopsia may occur with impairment of visual acuity. A low visual acuity does not necessarily mean detachment of the macula but may be due to a balloon detachment above, overshadowing the macula. The intra-ocular tension should be taken, cases of detachment with large tears usually have a rather low tension.

Vision test

Slit-lamp examination is essential for the anterior vitreous and if possible an attempt should be made, by use of a contact glass and an offset microscope, to observe any vitreous detachment or changes in the retina. About 5 per cent of detachments are ushered in by a vitreous haemorrhage. The significance of this is sometimes not understood and the condition is attributed to arterio-sclerosis. Slit-lamp examination may disclose the typical golden points of reflection in the anterior part of the vitreous depicting haemorrhage or the beam may show a reddish hue of blood in the anterior vitreous; the vessels appear to be darker in colour and narrower in calibre than normal. A retinal tear is a window in the detachment opening upon the choroid. Through the tear may be seen details of the choroidal pattern which may show atrophic and pigmentary changes.

Vitreous haemorrhage

The field of vision of the affected eye should be taken by the perimeter. This will reveal a scotoma roughly corresponding to the area of detachment, but occasionally a larger field is obtained than the size of the detachment seems to warrant In such cases, usually of recent origin, the detached retina is still responsive to a stimulus of such intensity as a half-degree white object.

Scotoma

(6) Differential diagnosis

It is necessary to distinguish a simple detachment of the retina from (a) an exudative detachment, and (b) a detachment due to a malignant melanoma of the choroid.

(a) Exudative detachment

An exudative detachment is usually discovered as a feature in some serious general disturbance such as a renal failure from nephritis or from pregnancy toxaemia. The eye condition improves under effective treatment of the general state of the patient.

Site

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(a) *Exudative detachment*

An exudative detachment is usually discovered as a feature in some serious general disturbance such as a renal failure from nephritis or from pregnancy toxaemia. The eye condition improves under effective treatment of the general state of the patient.

(b) Malignant melanoma

Malignant melanoma, unlike simple detachment of the retina, shows as a dark sharply-demarcated swelling in the fundus unaffected by gravity. Its surface is without waves or tremor on movement of the eye. A most important feature of a tumour is irregular pigmentary mottling of the retina due to irritant action of the underlying growth upon the pigment-cell layer of the retina. Such tumours may be complicated by the appearance of a shallow fluid detachment below, probably due to choroidal exudation but unaccompanied by a tear. The eye cannot be transilluminated by application of a point of light on the sclera over the area of a tumour, whereas in a simple detachment, transillumination causes a red glow in the pupil. When the intra-ocular tension is raised a tumour may be suspected. *Transillumination*

(7) Prognosis

Prognosis is adversely affected by long duration of a detachment, by large tears and by low intra-ocular tension and the presence of complicated cataract. Among patients who submit to cataract operations, 2 per cent develop detachment of the retina within 5 years of operation and this incidence rises to 10 per cent when vitreous has been lost at the time of operation. Aphakic detachment has a poor prognosis. An important aspect in prognosis is the prospect of recovery of macular vision. The macula is detached in 50 per cent of cases and provided the detachment is of not more than three months' duration, the vision recovered is about 6/18. Detachments of longer duration may be expected to recover fair fields of vision with a good anatomical reposition of the retina but with grossly defective central vision. Published results of the treatment of detachment of the retina differ widely but it may be accepted that in a large unselected series of cases of all kinds between 50 and 60 per cent will be replaced. *Cataract* *Macula*

(8) Treatment

An account of detachment of the retina would be incomplete if it omitted a tribute to the epoch-making work of Jules Gonin who suggested the closure of retinal tears by cauterization as treatment for the condition Prior to the work of Gonin, treatment had been empirical, often hazardous, almost always ineffectual, and generally led to blindness

The first need is to immobilize the patient in bed. Both eyes are bandaged and the head is held between sandbags so that the area of detachment is at the most dependent point; for example, detachments in the upper temporal quadrant, the most common site for a tear to occur, require the patient to lie on the affected side without a pillow and with the foot of the bed raised. After a period of rest the fluid separating the retina is partially or wholly absorbed, causing marked changes in the fundus appearances. When the detachment spontaneously disappears, no operation may be needed This fortunate outcome occurred in 5 per cent of the author's cases Such patients should remain in bed with the eye bandaged for 14 days and then be permitted to get up for a short time, increasing the period each day. *Operation not always necessary*

The initial period in bed is used in the search for tears and it may be assumed that if the detachment has not disappeared after a week of expectant treatment, no further change will occur and an operation will be required.

Principles of treatment

It is necessary in this work only to indicate the principles of treatment. The object of the many operations that have been proposed is to cause an artificial choroiditis over the region of the detachment. After evacuation of

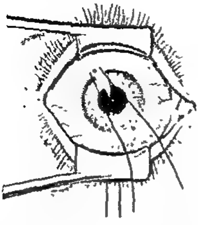

FIG. 224.—Eye showing traction suture in position. Marks indicate meridian of tear.

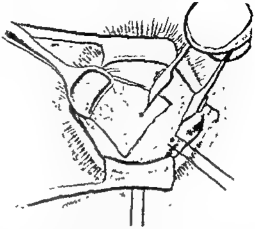

FIG. 225.—Eye drawn downwards showing conjunctival flap reflected with calipers in position marking site of tear.

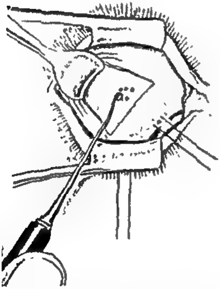

FIG. 226.—Application of diathermy puncture in a series of perforations surrounding the site of the tear in semicircular formation.

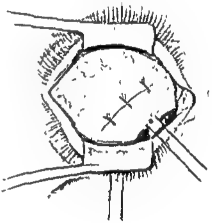

FIG. 227.—Conjunctiva sutured.

the fluid separating the retina from proximity to the choroid, the two structures come into close relation and the retina becomes adherent to the "tacky" choroid, the tear being occluded by exudation and later by fibrous tissue formation. The chief method in use today is to create a choroido-retinal adhesion by means of diathermy (Figs. 224–227). This may be by surface

Diathermy

application (Larsson, 1930), or by micro-puncture 1–2 millimetres long (Weve,

1936; Safár, 1934); the two methods are frequently combined. The operation is carried out under local anaesthesia and the effect of treatment is continuously observed by use of the ophthalmoscope throughout the operation. By such means, accuracy in localization of treatment is achieved and the local destruction of tissues is reduced to a minimum. If necessary, rectus muscles are divided to obtain good access to the surface of the sclera but there is always the possibility of a post-operative diplopia in division of the vertically acting recti. *Ophthalmoscopy* *Diplopia*

Attention is concentrated upon the tear and an attempt is made to surround it with micro-punctures or if the tear is a disinsertion, to wall it off by a series of micro-punctures posterior to it. When there is considerable fluid and little prospect of this oozing through the micro-punctures, it should be evacuated through trephine holes $1\frac{1}{2}$ millimetres in diameter, made through the sclera down to the choroid.

3. GLIOMA OF THE RETINA

(1) Definition

Glioma of the retina (retinoblastoma, neuro-epithelioma, medulloblastoma) is a malignant tumour which is regarded as arising from the common cellular ancestor of the neural and neuroglial elements of the retina In their histological detail, these tumours resemble certain growths of the brain of which the retina is an outlying island

(2) Incidence

Glioma is a rare tumour It may be present at birth and most cases occur during infancy, though no age in childhood is exempt. Statistics agree that 20 per cent of the number of cases are bilateral Many examples are witness to the markedly hereditary character of the disease. A striking instance reported by Newton (1902), is the family in which 10 out of 16 children had glioma of the retina, none of the 10 lived beyond the age of 5 years and in 7 cases the condition was bilateral Instances of the disease appearing in several generations have frequently been reported. *Hereditary character*

(3) Clinical course

The clinical course of the disease may be conveniently divided into three stages. These stages are where (a) the tumour is confined to the eye, (b) a raised intra-ocular tension is present, and (c) perforation and extra-ocular extension has occurred.

(a) Tumour confined to the eye

The first sign that is usually observed is a white reflection from the child's pupil A parent may notice this effect accidentally when the child's eye is in certain positions Focal illumination clearly reveals the outlines of a grey nodular tumour which may have vessels on its surface and, sometimes, may have a pinkish look. *Focal illumination*

The earliest signs of such a tumour are often revealed by inspection of the fellow eye When the disease is bilateral, the condition is usually more advanced in one eye than in the other

(b) Raised intra-ocular tension

At first there is to be seen a grey, round, raised area which may occur in any part of the fundus. Such a tumour may grow inward (glioma endophytum) and fill the vitreous with a flocculent mass, or it may grow outward (glioma exophytum) invading the choroid and causing extensive detachment of the retina. Seedling tumours may be found scattered over the fundus and particles may be swept forward into the anterior chamber and become deposited upon the iris and the posterior surface of the choroid. By the time the disease has developed to this degree the intra-ocular tension may be raised, causing symptoms of glaucoma, with pain, ciliary congestion and haziness of the cornea.

Seedling tumours

(c) Perforation and extra-ocular extension

Finally the tumour may perforate either the cornea or the sclera. If the former occurs the eye may be replaced by a necrotic haemorrhagic mass parting the eyelids. The sclera is fairly resistant to infiltration by the tumour but it becomes thinned by the increased intra-ocular tension and its permeation so made easier. The tumour reaches the orbital tissues by way of those canals which convey nerves and vessels through the sclera. The invasion of the orbit causes exophthalmos and restriction of eye movements in the course of time. An important route of spread is along the optic nerve Reese (1931) found, in 119 eyes with no extra-ocular extension, that 63, or 52 per cent, were affected by invasion of the nerve posterior to the lamina cribrosa. This extension was found in some of the smallest tumours and its possibility has a profound effect upon treatment and prognosis.

Orbit invasion

Bilateral character

The importance of the bilateral character of the disease cannot be overstressed. Careful and repeated examination of the second eye under an anaesthetic is needed, as shown by a patient recently under the author's care. This child had an advanced tumour in one eye and no abnormality in the other eye. Within three months the second eye showed a prominent tumour.

(4) Pathology

Tumours of the retina appear to arise in nests of primitive retinal cells which may be located in the outer nuclear layer of the retina and show in section as a fusiform expansion of this layer.

Tumour cells

The histological picture is one of tumour cells of rounded or polygonal form often massed as a "mantle" around blood-vessels. The cells have large deeply-staining nuclei and little cytoplasm. They tend to be arranged in rosette fashion around an empty lumen. These embryonic growths are highly malignant and are subject to patchy necrosis, fat deposition and calcification.

Calcium deposits

Pfeiffer (1936), by means of x-rays, examined a series of enucleated eyes affected with glioma and he found that 15 out of 20 specimens showed shadows cast by calcium deposits He then examined a series of eyes before enucleation and found calcium-deposit shadows, in 8 out of 10 eyes, in cases of glioma proved by section. In 2 cases without a shadow the growth was at an early stage. These degenerative changes usually do not influence the relentless advance of a glioma, but there exists the slight possibility of complete involution. Cases have been recorded in which excision of an eye has been refused and the individual has survived to adult life.

Hine (1937) describes the cases of a father and son in both of whom there was the spontaneous retrogression of a glioma. The fundus appearances in these cases are of a rounded, sometimes craggy, grey-white patch surrounded by a zone of choroido-retinal atrophy.

(5) Differential diagnosis

A condition resembling glioma may arise from a low-grade metastatic infection due usually to a specific fever. The term pseudoglioma has been used to describe these cases, which present a grey-white appearance with a flattened surface unlike the often polypoid and pink-white glioma. It is well to remember that a glioma may coexist with inflammatory signs such as exudates on the posterior corneal surface and with adhesions of the pupil to the lens. In addition, certain congenital abnormalities connected with the fibro-vascular sheath of the lens; infantile exudative detachment of the retina and so-called retro-lental fibroplasia may present as a white mass lying immediately behind the lens. Such eyes are nearly always blind and the best policy is their excision because there can be no certainty of diagnosis without histological examination. *Pseudoglioma* *Retro-lental fibroplasia*

(6) Prognosis

The prognosis probably depends upon the degree of invasion of the optic nerve and the site of section of this nerve on excision of the eye. Reese (1931), found that in 81 per cent of cases in which invasion of the nerve had occurred, the section had fallen short of the furthest extension of the growth and he estimated that in 43 per cent of apparently favourable cases without extra-ocular extension, active tumour was left behind in the stump of the nerve. This means that the survival rate of clinically favourable cases is about 60 per cent, and this figure is confirmed in the report of Leber (1916) *Optic nerve*

(7) Treatment

When glioma affects one eye only, there can be no alternative to excision including a large portion of the optic nerve. It is necessary to obtain an early histological report upon the nerve and if there is evidence that the nerve has been divided distal to the limits of the tumour, then all the soft tissues of the orbit should be removed by exenteration. It is well to remember that it has been shown by Meighan and Michaelson (1938), that glioma in the course of its spread along the optic nerve may leave apparently healthy segments. Consequently, in every case after excision, a course of irradiation of the socket should be given When there is bilateral glioma, the eye with the more advanced growth should be removed and the other eye treated by radium. Radiation treatment, when first introduced, had such poor results that it was justified only because it avoided the tragic alternative of advising the excision of both eyes in an infant. Stallard (1948) in a recent paper says that the treatment of glioma retinae is under trial with changes in technique and the dose is at present empirical. It seems that a dose of 3,500 r is effective in destroying this very radio-sensitive neoplasm The author's present method is to use 1-centimetre radium needles each containing 0 6 milligram of radium screened by 0 5 millimetre platinum. These needles are fixed by sutures to the outer surface of the exposed sclera over the tumour to give a dose of 3,500 r over 10 days. *Exenteration* *Irradiation*

REFERENCES

Hine, M. L. (1937) *Trans. ophthal. Soc. U.K.*, **57**, 173.
Larsson, S. (1939). *Acta ophthal., Kbh.*, **8**, 172.
Leber, T. (1916). *Graefe-Saemisch-Hess Handbuch der gesamten Augenheilkunde*, 2nd ed., Vol. 7. Leipzig; Engelmann.
Meighan, S., and Michaelson, I. C. (1938). *Trans. ophthal. Soc. U.K.*, **58**, 208
Newton, R E. (1902). *Lancet*, **2**, 1411.
Pfeiffer, R. L (1936). *Arch Ophthal., Chicago*, **15**, 811.
Reese, A. B. (1931). *Arch Ophthal., Chicago*, **5**, 269.
Safár, K (1934). *Arch Ophthal., Chicago*, **11**, 933.
Stallard, H. B. (1948) *Brit. J. Ophthal.*, **32**, 618.
Weve, H. (1936) *Arch Ophthal., Chicago*, **16**, 173.
[References to other titles are given under Retina in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol. 10, p 611]

SACRO-COCCYGEAL REGION—SURGERY OF

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1. DEVELOPMENTAL ANATOMY

297.] Most of the lesions particular to the sacro-coccygeal region arise from vestigial embryonic tissue. The potentialities of this region are due to the fact that the primitive streak or node occurs here, and from this part all the fundamental systems of the body grow forward During embryonic development it remains for a long time a point of fusion of the central nervous

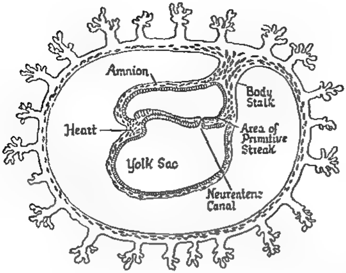

FIG. 228.—Longitudinal sectio of embryo in third week.

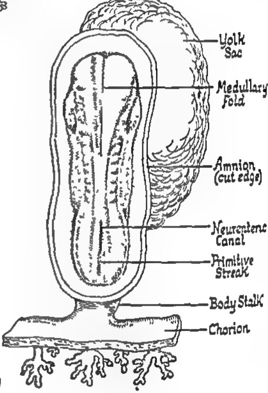

FIG. 229.—Dorsal surface of embryo at end of third week.

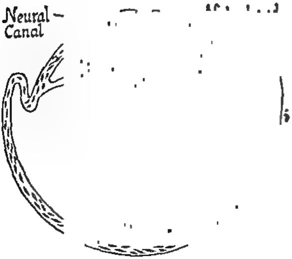

FIG. 230.—Diagrammatic cross section of embryo to show formation of notochord.

system, skeletal axis, segmental musculature and post-anal gut. Nowhere in the body are there greater possibilities of malformation.

At the end of the third week of development the embryo is represented by a plate—the embryonic plate (Fig. 228). At the hinder end of the dorsal surface of the plate a linear groove—the primitive streak (Fig. 229)—appears and at its front end a perforation—the neurenteric canal (Fig. 229)—joins the amniotic cavity to the primitive gut. *Neurenteric canal* The neurenteric canal is afterwards included in the neural groove and might be represented by a remnant passing from the rectum to the sacral region of the spinal canal, but so far no vestigial structure, which is for certain of this nature, has been recognized. The posterior end of the primitive streak is marked by another important structure—the cloacal membrane.

In front of the neurenteric canal the ectoderm is folded in to form the medullary tube. *Medullary tube* Beneath the medullary tube there is a plate of cells along the median line in the roof of the primitive gut cavity which becomes folded off from the gut cavity to form a rod of cells—the notochord (Fig. 230). *Notochord* At first the notochord is hollow—its hinder end opening at the neurenteric canal—later it becomes a solid rod of cells and is continued in the primitive streak and later still in the growing tail. From the second month of foetal life the notochord begins to disappear—the bodies of the vertebrae and its cartilage forming round it and constricting it. Only in the intervertebral discs does the notochord normally persist; here it swells out to form part of the central mucoid core. At the cranial and caudal ends, however, vestigial remnants are not uncommonly found.

In the fifth week the growing caudal point, containing the neural canal, notochord and cloaca, is being extended backwards, and at the end of the sixth week the human tail has reached its maximum growth—projecting fully one millimetre and equal to a tenth of the long diameter of the embryonic body. Thr [illegible]
marks th [illegible]
extends t [illegible]
transitory tail gut which disappears in the second month of development. *Tail gut* Remnants of the tail gut may give rise to some of the congenital tumours which arise in front of the coccyx and sacrum.

2. SACRO-COCCYGEAL (PILONIDAL) SINUS

(1) Definition

Sacro-coccygeal sinus is a chronic or recurring sinus opening on the midline of the back about the level of the sacro-coccygeal joint. The sinus frequently contains a tuft of hairs, and this explains the term pilonidal sinus—"nest of hairs".

(2) Aetiology

The condition is relatively common—I have seen an average of 20 cases each year. It seems to be even commoner in the United States of America, where large series have been reported by a number of authors.

The condition is almost three times as common in males as in females. *Sex* It may occur at any age, but in the great majority of patients is first noted

Age

between the ages of 18 and 25 years. In females symptoms start on the average at an earlier age than in males. There is little evidence of any familial tendency.

Hairiness

A great many of the patients are exceptionally hairy; many are very obese and may suggest hypopituitarism.

Most of the patients are dark or black-haired. Blonds seem to be immune; I have only seen two fair-haired patients in a series of over 200 pilonidal sinuses. The condition is particularly a disease of the white races.

Trauma

Frequently repeated minor traumas, such as bumping or rubbing on hard seats, are important factors in causing the sinus to produce symptoms which draw attention to its existence. The frequency of pilonidal sinus in the American mechanized forces led to the condition being referred to as "jeep disease".

"Jeep disease"

A clear indisputable explanation of the formation of pilonidal sinus is not yet available, though it is commonly agreed that it is the result of alterations in embryonic development. There are three theories as to its origin. (1) Imperfect coalescence of the two halves of the body. (2) Failure of the medullary canal to become obliterated over the sacrum. (3) Invagination of the ectoderm at the lower end of the sacrum.

(3) Morbid anatomy

Primary sinuses

The primary sinus is a tubular structure lined by squamous epithelium. It leads into a cavity partly lined by skin and partly by granulation tissue. If secondary sinuses have formed they will be found to lead off from the cavity and they are always lined by granulation tissue.

Secondary sinuses

Hairs

Hairs are present in nearly 50 per cent of the specimens, especially in those cases with the shortest histories—inflammation results in loosening and discharge of the hairs.

Complications

Complications are rare apart from recurring attacks of inflammation. In a few cases the sinus has communicated with the spinal canal and meningitis has occurred, and in one or two cases epitheliomatous changes have been noted.

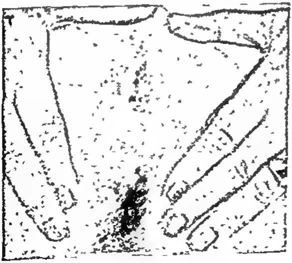

FIG. 231.—Multiple primary sinuses.

The infecting organism is most commonly a streptococcus, less often a staphylococcus, and very rarely *Bacillus coli.*

(4) Clinical picture

Before they become infected the sinuses are symptomless and seldom noticed by the patients. When infection occurs the patient complains of pain, swelling, or discharge from the "bottom of the spine". Usually there is a history of repeated attacks of abscess formation, the

Repeated abscesses

abscesses having burst or having been incised, only to recur again and again.

Number of openings

The primary sinus appears as a single or, more commonly, multiple opening exactly in the midline of the back at about the level of the sacro-coccygeal joint (Fig. 231). In size the opening varies from 5 millimetres to a minute hole so small as to look like a tiny "blackhead".

The sinus runs upwards towards the sacrum and ends blindly. It does not reach bone and is superficial to the gluteal muscles.

When infection occurs all the signs of local inflammation may be noted, going on to cellulitis and abscess formation. The pus may be discharged from the primary openings or, more commonly, it tracks to the surface and bursts through the skin to one side of the midline.

Secondary sinuses

The secondary sinuses, which never open exactly in the midline, are ordinary fistulous openings with ragged ulcerated orifices, and lined by granulation tissue (Fig. 232). There is generally only one secondary sinus, but sometimes cases are seen with multiple secondary sinuses opening on the thigh, groin or perineum. For some unexplained reason the majority (85 per cent) of secondary sinuses open to the left side of the midline.

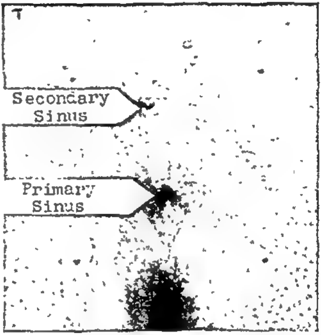

FIG 232.—Single primary sinus with secondary sinus on left side.

(5) Differential diagnosis

If one is aware of the existence of the condition, diagnosis is easy, for it is a case of "once seen, never forgotten". The typical primary openings are unmistakable.

Fistula-in-ano

The condition is most commonly mistaken for a fistula-in-ano, but the fact that a probe in the sinus runs upwards towards the sacrum and not towards the anus makes the correct diagnosis clear.

(6) Indications for surgical treatment

Once it has started to cause symptoms, a pilonidal sinus will continue to do so and there will be periodic pain and discharge. Non-surgical treatment, such as caustics and radiotherapy, has been signally unsuccessful, so that surgical treatment is indicated in almost every case that has become infected.

Unfortunately the results of surgical intervention have been far from satisfactory. Recurrences are frequent and healing is slow.

Excision

As the sinus is lined by epithelium it must be either excised or marsupialized.

Marsupialization

Marsupialization is a relative newcomer to the list of techniques which have been suggested for dealing with pilonidal sinuses. Large series of cases have been reported by some American surgeons; their results are striking. The method is certainly worthy of trial but whether it will give as satisfactory results, in the hands of the surgeon who has only an occasional case to deal with, remains to be seen.

(7) Pre-operative management

The bowels should be prepared as for an operation on the rectum. It is advisable to start the patient on sulphonamides and penicillin the day before operation, and to continue this chemotherapy for 4–5 days afterwards.

Chemotherapy

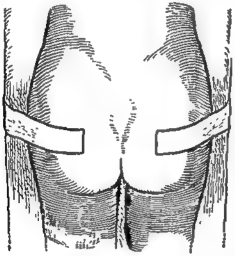

FIG. 233.—Method of retracting buttocks.

When there is acute inflammation this must be treated by penicillin and, if necessary, by incision and the radical operative treatment postponed until the inflammation has resolved.

(8) Operation

Any form of anaesthesia may be used. The patient is placed in the prone position with a pillow under the front of his pelvis. The buttocks are retracted by Elastoplast strips stuck to the sides of the table (Fig. 233). The anal orifice is covered by a swab soaked in flavine solution.

Some surgeons attempt to delineate the track by x-ray examination after injection of Lipiodol or by injecting dyes or melted wax. Such methods are misleading and unnecessary.

(a) *Excision*

Extent of excision

An elliptical incision is made to include all the primary and secondary openings. If there are no secondary openings an ellipse of tissue 2 centimetres wide passing 1 centimetre below the lowest primary opening and 1 centimetre above the highest opening—or 5 centimetres above if there is only one opening—will usually remove all the diseased tissue. If there are any secondary sinuses the incision must pass 0·5 centimetre external to them (Fig. 234). When any secondary opening is more than 1·5 centimetres from the midline it will be easier to excise it by making a lateral wedge-shaped incision at right angles to the main one. If the incision is made from below upwards, it will be easier to avoid a ragged, bevelled cut. The incision is deepened down to the fascia on the dorsum of the sacrum and to the gluteal muscles, and the elliptical area is removed *en bloc*. After excision the wound must be carefully examined to make sure that no diseased tissue, which is greyish and gritty, is left behind.

Haemostasis is secured by firm pressure with hot packs and forci- *Haemostasis* pressure. No ligatures should be used—with patience and pressure none is needed.

Unless primary suture is indicated the wound is now loosely packed with sulphonamide tulle and covered with a voluminous wool pressure dressing held in place by Elastoplast.

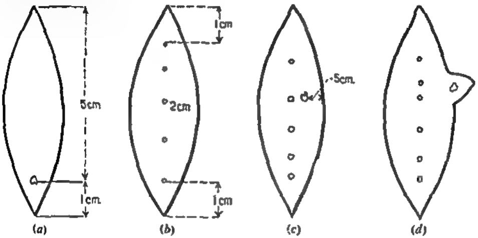

FIG. 234.—Diagrams showing areas of skin to be removed for: (*a*) Single primary sinus, (*b*) multiple primary sinuses, (*c*) secondary sinus opening close to midline, and (*d*) secondary sinus opening at a distance from midline.

(*b*) *Excision and primary suture*

There can be no doubt that the ideal treatment is complete excision with primary closure of the wound. When successful this method is a great saving

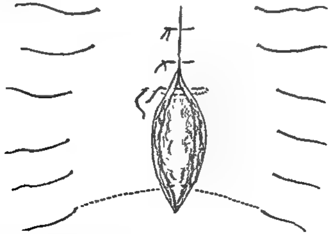

FIG 235 —Primary suture after excision Method of placing sutures.

in time and in dressings but unfortunately in the hands of most surgeons the results have been disappointing—a high percentage of the cases breaking down or recurring. The average surgeon will be well advised to attempt

primary suture only in those cases which are clean and quiescent and in which no secondary sinuses are present.

If it is decided to attempt primary suture, the preparation and excision are done as already described. Haemostasis must be perfect and must be attained by forcipressure and hot packs; ligatures must not be used. Unless the wound sides will come together without tension, primary suture must not be attempted.

Obliteration of dead space

Obliteration of the dead space in the wound is the most essential and most difficult step in the operation. Buried sutures—especially catgut—should not be used. The method illustrated in Figs. 235 and 236 has been found satisfactory. A series of strong interrupted silkworm-gut sutures are inserted

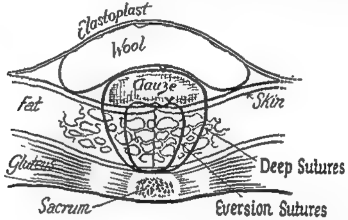

FIG 236.—Primary suture after excision: Cross section showing arrangement of sutures and dressing

through and through from side to side, taking a firm bite of the ligaments on the dorsum of the sacrum—these sutures are left untied until later in the operation. A second row of silkworm-gut sutures is inserted; these should be of the vertical mattress type to ensure accurate apposition of the skin edges Before tying the mattress sutures the wound is inspected to make sure that all bleeding is controlled, and it is then lightly dusted with penicillin powder. When the mattress sutures are tied, a thick roll of gauze is laid along the wound and fixed in place by tying the through-and-through sutures over it. Over the gauze a voluminous layer of wool is fixed in place by strips of Elastoplast.

(c) *Marsupialization*

The pilonidal sinus lining is ectodermal in origin and should, therefore, contain the elements from which skin can be formed.

A probe or grooved director is inserted into the sinus and the skin slit along its course. Any secondary sinuses are treated in like manner. The overhanging edges are cut away along with a portion of the lateral wall of the cyst or sinuses. The remaining portion of the sinus is cleaned with gauze. The skin edges are now loosely sutured to the edges of the remaining cyst wall. The wound is lightly packed with sulphonamide tulle and a wool pressure dressing applied.

(9) Post-operative care

(a) Excision and marsupialization

The original dressing is retained for 4–5 days, the bowels are then opened and the patient is started on twice-daily baths. After each bath the wound is repacked lightly with sulphonamide tulle.

Should any small tracks be missed at the time of operation, these will become obvious during the early post-operative period and, with a little local anaesthetic, they can be "unroofed".

(b) Excision and suture

Twice a day the anal region is swabbed with flavine and a swab soaked in the antiseptic is placed there. The deep sutures and half the mattress sutures are removed after 8–10 days, and the next day the remaining sutures are removed. The buttocks are kept strapped together for another 8–10 days.

If at any time it becomes clear that the wound has become infected then all sutures must be removed without delay, the wound opened out and lightly packed with sulphonamide tulle.

(10) Results of surgical treatment

Simple incision invariably results in recurrence.

Healing following excision of the sinus is an extremely slow process, taking on an average 3 months.

Primary suture, when successful, results in sound healing within 3 weeks Though many successful series of cases have been reported, the majority of authors confess to obtaining primary union in less than 50 per cent of cases.

Marsupialization is claimed to allow the patient to get up and go home within a few days and to result in healing within 3–6 weeks.

3. SACRO-COCCYGEAL TUMOURS

(1) Definition and aetiology

In the sacro-coccygeal region various types of tumours are found as the result of anomalous development in the early embryo, or the persistence of rudimentary structures. These tumours are nearly always congenital and are practically confined to female patients. *Females*

Anomalies in the early embryo may give rise to parasites as the result of two embryonic areas forming in a single blastomere, one developing normally and completely as the autosite, the other remaining ill-formed as the parasite. Two main types of parasite inclusions are recognizable.

(i) *Parasites.*—These are formed of definite organs ranging from complete conjoined twins to externally attached parasites consisting of small, incomplete, stunted portions of a limb

(ii) *Teratomas.*—Teratomas are solid or cystic tumours arising in front of, or behind, the sacrum or coccyx and consisting of an irregular confusion of a great variety of tissues or parts of organs derived from all the embryonic layers.

Tumours may also arise in this region from vestigial remains of the notochord, neurenteric canal or post-anal gut, producing chordomas, ependymal gliomas or dermoid cysts.

All of these sacro-coccygeal tumours show a remarkable absence of any hereditary proclivity.

(2) Morbid anatomy

Conjoined twins commonly have the lower ends of their spines joined, but in some cases they are united by the soft parts only. The majority are still-born but a few survive to adult life.

The extremity-producing parasites may be externally attached or completely, or partially, included. Their attachment is commonly to the back of the sacrum or coccyx and the union is usually osseous.

The teratomatous tumours are localized, especially round the coccyx to which they are commonly united, in front or behind. Some contain unmistakable foetal parts such as intestine, limbs or vertebrae.

Much more commonly the teratomas consist of histioid structures only. These are often large, have a broad attachment, are frequently cystic and are prone to inflammation and sloughing. They usually lie in front of the coccyx but have no joint or osseous connexion with this bone. Derivatives of the nervous system form the commonest content of the tumours. Enteroid or tegumentary structures are also common but teeth are rare.

Malignant changes

Malignant changes have been found to develop in nearly 10 per cent of these lowly organized sacro-coccygeal tumours—a marked contrast to the more highly developed types.

(3) Clinical picture

The externally attached parasites frequently cause dystocia, which is fatal to both the autosite and the parasite. If they survive birth the autosite's health is not usually impaired.

The teratomas may be very prominent at birth or cause little external swelling for a time They are often noted for the first time on making a rectal examination to find the cause of constipation. They may suppurate and be mistaken for an ischio-rectal abscess or fistula-in-ano. If in front of the sacrum and coccyx they develop forwards and downwards between the legs. Rarely if ever do they extend up into the abdominal cavity.

(4) Indications for surgical treatment

Surgical treatment depends on the type, size and position of the tumour. Removal is indicated on account of rapidity of growth, large size, disfigurement, suppuration, or to prevent suppuration.

In the case of sacral parasites any connexion between the parasite and the vertebral column of the autosite must be looked for. The caudal appendages are readily removed

The teratomatous tumours and cysts are generally encapsulated and can be shelled out. Infection may, however, make their removal difficult. A posterior approach of the Kraske type is usually indicated.

4. CHORDOMA

(1) Definition and aetiology

A chordoma is a tumour of low malignancy derived from remnants of the notochord (*see* Vol. 3, p. 51). While a chordoma may occur wherever residual

Site

notochordal tissue occurs—the spheno-occipital or sacro-coccygeal regions or the intervertebral discs—more than half of them arise in the region of the sacrum.

Although no age is exempt, the majority of chordomas occur in the fifth decade, and males suffer more frequently than females. *Age* *Sex*

(2) Morbid anatomy

A typical chordoma is a slowly growing, well defined, lobulated tumour consisting of bluish-white gelatinous tissue with areas of haemorrhage and cystic degeneration.

The tumour may arise in front of, or behind, the sacrum or coccyx which it involves or destroys.

Microscopically there are alveolar masses of polyhedral cells which characteristically show large vacuoles from intracellular mucin formation (Fig. 237). *Histology*

In many tumours, especially slow-growing ones, large portions of the growth may be replaced by gelatinous tissue.

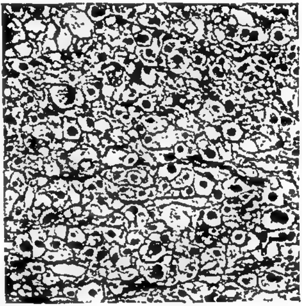

Fig. 237.—Chordoma Section of a chordoma from sacrum showing vacuolated cells (× 350)

Though invasive and almost always fatal, chordomas do not often metastasize widely, but secondary growths in the liver, glands, lungs and skin have been recorded in about 10 per cent of cases. *Metastasis*

The tumour is usually very slow growing but may attain a very large size, some of the recorded cases being over 80 centimetres in circumference and 200 ounces in weight. Though there have been cases in which chordomas have ulcerated into the rectum, those that project posteriorly seldom ulcerate through the skin.

(3) Clinical picture

Pain, which later may become severe, is the earliest and commonest symptom. In the advanced stages pressure on nerves may lead to paralytic and trophic disturbances or to interference with micturition or defaecation.

X-ray examination will show some sign of sacral destruction in almost every case.

(4) Indications for surgical treatment

In spite of the bad ultimate prognosis, an attempt at excision of a chordoma should be made. Even partial removal is worth trying, as it often results in symptomatic improvement.

Most cases eventually reach a stage at which the severity and persistence of the pain calls for bilateral spinothalamic chordotomy.

5. COCCYDYNIA

(1) Definition

This condition is characterized by pain of a more or less severe character in the region of the coccyx.

(2) *Aetiology and morbid anatomy*

The condition has been ascribed to various causes. It certainly may be the result of an injury and in some cases the coccyx is found to be deformed, and there may be either no movement or arthritis in the sacro-coccygeal joint. Pain may also be due to adhesions in the joint or to inflammation of the nerves close to the side of it. In the majority of cases no definite cause can be discovered. It is commoner in females than males, and the lean rather than the stout.

Injury

Arthritis

Neuritis

(3) Anatomy

Muscle attachments

There are four important muscles attached to the coccyx—the gluteus maximus posteriorly, coccygeus in front, the levator ani to the tip behind and the sphincter ani to the tip in front—but these do not suffer by removal of the bone as they have other, and more important, attachments.

Nerve plexus

The coccyx has close relations with the coccygeal nerve plexus, which is formed of fibres from the fourth and fifth sacral and the coccygeal nerves and the inferior haemorrhoidal branch of the internal pudic nerve.

(4) Clinical picture

Pain

The patient complains of pain in the region of the coccyx, especially on sitting. The pain is usually spasmodic. Quite often the pain is worse when sitting on a soft, rather than a hard, chair.

On rectal examination there may be deformity of the coccyx or undue sensitiveness or tenderness on manipulating this bone.

(5) Differential diagnosis

Many lesions in the rectum or genitalia cause pain in the coccygeal region, and these must be excluded.

(6) Indications for surgical treatment

In some cases the pain gradually settles down if the coccyx is relieved from pressure for a time.

Alcohol injection

Alcohol injections will relieve many cases. This treatment is carried out as follows.

The point of maximum tenderness is determined by palpation of the tissues between the index finger inside the rectum and the thumb outside. A long fine needle is then passed through the skin and guided down to the tender spot, and 10–20 minims of 80 per cent alcohol injected slowly. A single injection will sometimes cure the patient, but more often several injections at weekly intervals will be required.

Excision of coccyx

If the more conservative methods of treatment fail, the coccyx should be removed at the sacro-coccygeal joint. The wound is closed by silkworm-gut sutures following the same principles as are used in excision and suture of a pilonidal sinus.

BIBLIOGRAPHY

Brindley, G. V. (1945). *Ann. Surg.*, **121**, 721.
Buie, L. A. (1944). *Sth med. J., Nashville*, **37**, 103.
Faust, D. B., Gilmore, H. R., Jun., and Mudgett, C. S. (1944). *Ann. intern Med.*, **21**, 678.
Newell, R. L. (1933). *Brit. J. Surg.*, **21**, 219.
Oldham, J. B. (1941). *J. R. nav. med. Serv.*, **27**, 34.
Stewart, M. J., and Morin, J. E. (1926) *J. Path. Bact.*, **29**, 41.
Whittaker, L. D., and Pemberton, J. de J. (1938) *Ann. Surg.*, **107**, 96.
[References to other titles are given under Surgery of the Sacro-coccygeal Region in the Index Volume.]

SALIVARY GLANDS

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1. CONGENITAL ABNORMALITIES AND MALFORMATIONS

298.] Congenital abnormalities and malformations are uncommon, but the following have been recorded.

(1) Absence of one or more glands.
(2) Imperfect migration of the parotid gland or the submaxillary gland.
(3) Hypertrophy of any of the larger glands.
(4) Duct abnormalities and external fistula of the parotid gland.
(5) Ranula.
(6) Haemangioma, lymphangioma and cysts of the parotid gland.

2. RANULA

(a) Definition

The term "ranula" is applied to cystic swellings of the floor of the mouth and of the under-surface of the tongue, caused by blockage of small salivary glands.

(b) Aetiology

Congenital submaxillary ranulae are rare. The aetiology of the acquired type is uncertain but a few are traumatic or they may follow dental treatment, local operations or infection.

(c) Surgical anatomy

A ranula is a superficial structure covered by buccal mucosa; it may affect the gland of Nuhn and Blandin.

(d) Pathology

The projecting part is composed of buccal mucosa lined by a flattened layer of epithelium, while the deeper part is composed of the cyst wall adherent to the subjacent tissues.

(e) Clinical picture

The patient comes under observation on account of a soft swelling in the floor of the mouth. In some instances the swelling may rupture with the discharge of mucoid material. After a period of quiescence, the enlargement and rupture again occur. *Rupture*

Examination reveals a purplish, thin-walled, cystic swelling in the anterior part of the floor of the mouth, running over the surface of which are numerous fine blood-vessels. The swelling may be to one side of the midline if it is very small, but in most cases it reaches beyond this limit. It may encroach upon the inferior aspect of the tongue. The corresponding submaxillary duct is often displaced. A ranula of the gland of Nuhn and Blandin is entirely confined to the inferior aspect of the tongue. *Physical signs*

(f) Prognosis

Spontaneous cure after rupture is unusual and as a rule the condition persists until treated surgically.

(g) Operative technique

Complete removal is impossible owing to the difficulty of identifying the submaxillary duct. The superficial part of the cyst should be excised under general anaesthesia, the cavity swabbed with 1 per cent zinc chloride solution and packed with gauze which remains for 48 hours. Ranulae of the gland of Nuhn and Blandin necessitate complete excision, together with the underlying gland. Burrowing ranulae require a combined buccal and external operation.

(h) Results of treatment

Operative treatment gives excellent results provided the mucosal lining has been destroyed.

3. PTYALISM OR EXCESSIVE SALIVATION

(1) Definition

Ptyalism is a condition in which an excessive amount of saliva collects in the mouth.

(2) Aetiology

Ptyalism is a symptom of many diseases. It may be either true or false, according to whether an excessive amount of saliva is secreted or whether there is some disturbance in swallowing which causes the saliva to dribble from the mouth. *True or false*

(a) True ptyalism

True ptyalism occurs in the following conditions.

(1) Local diseases of the mouth, gums and fauces.

(2) As a reflex (a) in diseases of the oesophagus, stomach or duodenum; (b) in pregnancy; and (c) in trigeminal neuralgia

(3) In nervous diseases, such as bulbar paralysis or encephalitis lethargica.

(4) In acute specific fevers, such as smallpox, or hydrophobia.

(5) In disease of the salivary glands, such as syphilitic parotitis.

(6) In the insane, as in general paralysis of the insane, or melancholia.

(7) As the result of drugs such as mercury, pilocarpine and iodides.

(8) In pellagra.

(*b*) *False ptyalism*

False ptyalism occurs when the swallowing mechanism is interfered with. Examples of such interference are bilateral facial paralysis, *tic douloureux*, carcinoma of the tongue and functional conditions.

(3) Clinical picture

Excessive saliva causes serious local discomfort. It may necessitate the carrying about by the patient of a receptacle throughout the day into which to deposit his saliva, while at night sleep may be seriously disturbed.

(4) Treatment

Specific treatment is rarely called for. In the few cases for which treatment is indicated, atropine or irradiation may be of value. Avulsion of the auriculo-temporal nerve may have to be considered.

4. ACUTE PAROTITIS

(1) Definition

Acute parotitis (acute pyogenic parotitis, acute suppurative parotitis, acute non-epidemic parotitis or acute sialodochitis) is a bacterial infection of the gland by pyogenic organisms.

(2) Aetiology

Associated diseases

In most cases the condition is an ascending infection from the mouth. The disease generally occurs in conditions of dryness of the mouth, increase in the local bacteria and impaired mastication. The chief of these conditions are buccal or pulmonary infections, acute specific fevers, pyaemia, septicaemia, uraemia, peptic ulceration (especially during medical treatment) and the post-operative state. A few cases are secondary to a parotid calculus or recurrent parotitis. Cases secondary to direct extension or to haematogenous infection are rare.

Calculus

(3) Pathology

Bacteriology

The *Staphylococcus aureus* is the commonest organism, but the *Streptococcus pyogenes*, the *Str. viridans* and the pneumococcus are occasionally responsible.

The infective process starts in the main duct, which becomes obstructed by exudate and secretion, and the inflammation ascends through the smaller ducts, extends through the acini and gives rise to multiple minute abscesses. These may become confluent and rupture through the parotid fascia into the auditory meatus, pharynx, temporo-mandibular joint or great blood-vessels The gland becomes grossly enlarged.

(4) Clinical picture

Suppurative stage

In the catarrhal stage the gland is painful and slightly swollen, but there may be little fever. In the suppurative stage constitutional disturbance is severe, the gland is grossly enlarged, the subcutaneous tissues are oedematous, there may be oedema of the duct orifice and pressure over the gland may produce a flow of pus into the mouth (Figs. 238 and 239). In debilitated patients the clinical picture may be adynamic.

(5) Course and prognosis

The prognosis is partly governed by that of the associated condition, but the parotitis may prove the determining factor.

(6) Diagnosis

Diagnosis from mumps

An attempt should be made to obtain parotid secretion for examination, either by expression into the mouth or by catheterization. In mumps there is usually a history of contact, more than one gland is usually involved, second attacks are curiosities and there is no gross change in the saliva.

From other inflammation

Inflammatory swellings in connexion with the lower jaw, the adjacent subcutaneous tissues or lymph nodes may simulate acute parotitis.

FIG. 238.—**Acute suppurative parotitis.** Secondary to severe pyorrhoea The gland was drained externally and the pus contained a pure growth of *Staphylococcus aureus.*

(7) Treatment

Active early measures may avert operation. The diet should be as solid as the patient can manage. Dry heat should be used externally and hot mouthwashes internally.

Massage of gland

Gentle massage of the gland in a forward direction in the line of the duct may empty it of retained secretions. Danger to life is not usually great if pus can be emptied into the mouth.

Penicillin

Full doses of penicillin are indicated.

FIG 239—Acute parotitis and subcutaneous abscess. The parotitis was secondary to radium treatment of a carcinoma of the buccal aspect of the right cheek. The capsule of the gland has ruptured in the lower and anterior part and given rise to a large subcutaneous abscess This was drained, and the pus contained a pure growth of *Staphylococcus aureus.*

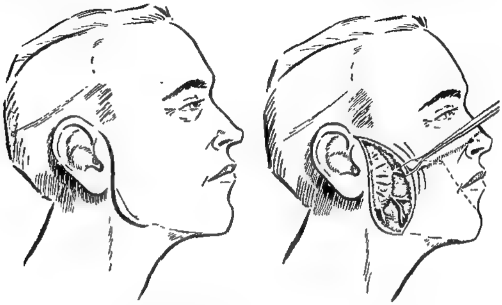
(8) Indications for surgical intervention

Operation is indicated when there is exquisite tenderness over the gland, oedema of the overlying tissues, the persistence of high fever with absence of duct secretion for more than 24 hours, failure to respond to penicillin, and any evidence of gross abscess formation. Death may occur while suppuration is still confined within the parotid fascia.

(9) Operative technique

Incision

The gland is exposed by an incision starting at the zygoma and passing downwards immediately in front of the ear, behind and below the angle of the jaw, and then forwards to the anterior border of the masseter muscle (Fig. 240). The skin and subcutaneous tissues are dissected forwards and the



(a) (b)

FIG. 240—(a) Lilienthal's incision for the exposure of the parotid in acute parotitis; (b) Lilienthal's incision showing direction of incisions in the parotid gland.

Adequate exposure

gland is exposed. Five or six radiating incisions are made into the parotid fascia in the line of the branches of the facial nerve, and the deeper parts of the gland are opened with Spencer Wells forceps. This approach exposes the gland adequately, gives excellent drainage and the resulting scar is negligible. Penicillin treatment has rendered early secondary suture possible.

(10) Complications

Facial paralysis may occur during very acute attacks. A salivary fistula is rare, owing to the inflammatory and destructive nature of the disease. Recurrent parotitis and the auriculo-temporal syndrome are occasional complications.

5. RECURRENT PAROTITIS

(1) Definition

Recurrent parotitis (recurrent pyogenic parotitis, recurrent sialodochitis, or recurrent enlargement of the parotid) *is a chronic infection of the ducts* causing recurrent attacks of glandular swelling.

(2) Aetiology

Impaired mastication

Women are especially affected. Impaired mastication is usually present and ... condition follows ... ; occurring

in infancy.

(3) Pathology

The *Str. viridans* is the commonest organism, with the pneumococcus second in importance. The catarrhal infection causes the saliva to become tenacious and mucoid, and from time to time to obstruct the ducts. *Bacteria*

(4) Clinical picture

The condition is usually unilateral, but it may become bilateral (Fig. 241) and even involve the submaxillary glands. Between the attacks of retention the gland is not necessarily enlarged, but its limits are often palpable. Periodically the gland becomes swollen and tender and it may take days or weeks to subside. The frequency and the severity of the attacks vary greatly, but constitutional disturbance is slight in cases due to the *Str. viridans.*

Fig. 241—Bilateral recurrent parotitis. From a man of 32 years of age with a 7 years' history of parotid swellings; he came under observation as a case of bilateral parotid tumours. The saliva from both parotid glands was turbid and gave a pure growth of *Streptococcus viridans*

(5) Course and prognosis

Suppuration is unknown in cases due to the *Str. viridans* (*see also* Pneumococcal Parotitis, p. 438). The attacks often tend to become more frequent and more severe. Xerostomia occurs if several glands are involved.

Fig 242—The cells found in a catheter specimen of saliva during the quiescent stage. (*By courtesy of the "Lancet"*)

(6) Diagnosis

This rests upon the clinical picture, examination of the saliva, and sialography. Cannula saliva is turbid owing to blobs of muco-pus. Microscopically, columnar or pavement epithelial cells are present, often containing bacteria (Fig. 242). The number of pus cells varies with the acuteness of the process. Cultures should also be made. *Saliva*

After "straight" skiagrams have excluded calculi, iodized oil should be injected into the duct. Globular or ovoid dilatations of various sizes may be present in the finest ducts, and segmental or fusiform dilatations in the larger ones (Figs. 243, 244 and 245). *Sialography*

Differential diagnosis

Recurrent mumps

The clinical picture and the investigations should establish the diagnosis. The condition is often diagnosed as recurrent mumps.

FIG. 243.—Sialograms: (a) normal; (b) in recurrent parotitis, showing globular dilatations.

(7) Treatment

In milder cases the patient may be kept almost free from attacks by getting *Mild forms* him to massage the parotid in a forward direction and in the line of the duct

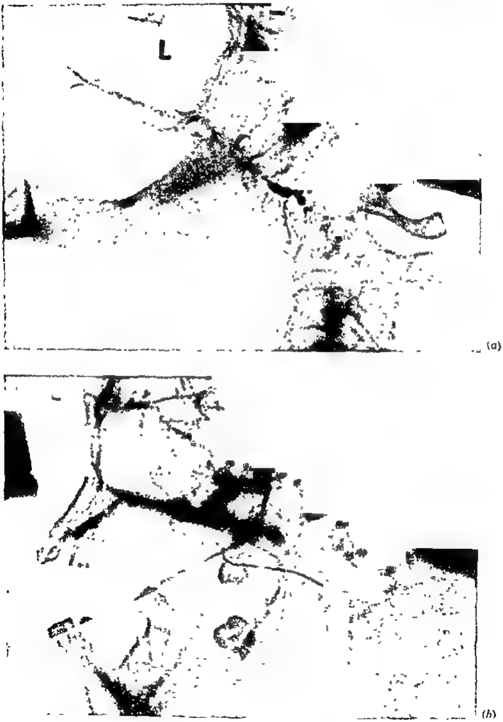


FIG 244—Sialograms in recurrent parotitis (a) shows segmental dilatations, and (b) a destructive lesion

for 5 minutes twice daily. Any local infection should be treated and an adequate chewing mechanism assured.

Severe forms Slitting and dilatation [illegible] tic [illegible] all tendency to contraction has passed. Penicillin treatment may be required. The results of auriculo-temporal avulsion are uncertain. X-ray treatment is useful in some of the milder *Str. viridans* cases. An acute exacerbation may be due to secondary infection and must be treated accordingly.

FIG. 245.—Left submaxillary sialogram from a case of recurrent infection involving all glands.

6. PNEUMOCOCCAL PAROTITIS

(1) Comparison with acute and recurrent parotitis

Pneumococcal parotitis occupies a position between acute staphylococcal parotitis and recurrent parotitis due to the *Str. viridans*. Recurrent enlargement of the parotid is characteristic, but the individual attacks are often acute, associated with constitutional disturbance and abscess formation. Sialograms show gross dilatation of the major ducts and irregular dilatation of the finer ducts.

(2) Prognosis

This is good as to life. There is much uncertainty as to the severity of the exacerbations.

(3) Treatment

This is described in the sections dealing with Acute Parotitis and Recurrent Parotitis (*see* pp. 433 and 437).

7. CHRONIC PAROTITIS

(1) Aetiology and pathology

Chronic pyogenic infections may follow acute or recurrent parotitis or be associated with a calculus. Rarely calcification may occur in chronic parotitis (Fig. 246). *Pyogenic*

FIG 246—Chronic parotitis showing calcification of parotids. From a woman of 30 years of age with Raynaud's phenomena and scleroderma

The specific infections include tuberculosis, syphilis and actinomycosis, but all are extremely rare and, with the exception of syphilis, usually start outside the parotid gland. *Specific*

(2) Diagnosis

Careful investigations of both local and general conditions are necessary. The local investigations include radiography, sialography, the examination of the saliva and possibly biopsy. The physical signs may closely simulate malignant disease. *Malignant disease*

(3) Treatment

This must be determined by the nature of the underlying disease.

8. AURICULO-TEMPORAL SYNDROME

(1) Definition

The auriculo-temporal syndrome (Frey's syndrome, or local hyperhidrosis of the face) is a condition of hyperaemia and sweating of the auriculo-temporal area following disease or injury of the parotid gland (*see* Vol. 5, p. 66).

(2) Aetiology

The syndrome is a rare complication of suppurative parotitis or injury of the parotid gland. Most of the reported cases followed parotitis during the course of typhus or typhoid fever. The condition may follow gunshot wounds or excision of a parotid tumour. *Parotitis* *Local injuries*

(3) Surgical anatomy

Area of involvement

The area of involvement is characteristically that supplied by the auriculo-temporal nerve and less often the areas supplied by the third division of the fifth nerve and the great auricular nerve.

(4) Pathology

The evidence suggests that the phenomena result from the establishment of connexions between parotid secretory fibres of the auriculo-temporal nerve and vasomotor and sweat secretory fibres in the same nerve.

(5) Clinical picture

The syndrome develops weeks or months after the original parotid lesion. *Hyperaemia and sweating develop during eating* as the result of a taste reflex from the tongue. Tingling or pain may occur, and the sweating may be enough for the moisture to trickle off the face. The area of involvement remains constant in the individual patient.

(6) Prognosis

The condition persists, but the amount of sweating may diminish slightly with age.

9. PAROTID CALCULI

(1) Definition

Parotid calculi or parotid sialolithiasis refers to discrete stones within the parotid ducts.

(2) Aetiology

Incidence

Parotid calculi are rare, submaxillary calculi being 40 times as common.

(3) Pathology

Chemistry

Calculi are usually single and vary from 1 to 5 millimetres in diameter, but occasionally large numbers are present. They are composed of calcium carbonate, calcium phosphate and traces of organic material. The calculi are

FIG. 247.—Chronic parotitis showing left parotid calculus.

situated either in the main or the smaller ducts, and dilatation takes place behind them. Some degree of infection is present.

(4) Clinical picture

Patients come under observation on account of recurrent enlargement of the gland or of some type of parotitis. The enlargement occurs during meals and subsides soon afterwards, and is accompanied by tightness of the gland. Residual swelling may persist. *Relation to meals*

(5) Course and prognosis

Untreated calculi eventually lead to one or other of the various types of parotitis. Minute calculi may be passed spontaneously.

(6) Diagnosis

Calculi may sometimes be palpated in the masseteric or buccal portions of the duct, or even in the gland itself. Sucking acid fruits may confirm the swelling of the gland. Stereoscopic skiagrams should be made, but the detection of calculi is difficult (Fig. 247) A catheter specimen of saliva should be examined to determine the nature of the infection. Sialography may help if the diagnosis is in doubt. *Difficulty of radiography*

(7) Treatment

Calculi in the buccal portion of the duct can be removed by incision of its medial wall from within the mouth. Those in the masseteric portion or in the intraglandular ducts must be approached externally (*see* Acute Parotitis, p 434). The calculus should be located digitally and fixed with needles. The duct should be repaired with two layers of fine ophthalmic catgut and the wound carefully sutured. Penicillin cover is indicated and parotid function should be depressed post-operatively. *Treatment of buccal calculi* *Of masseteric and intra-glandular calculi*

Acute parotitis secondary to a calculus should be treated on the lines indicated. There should be no attempt to remove a calculus during the acute stage unless it is situated near the duct orifice. *Of acute calculous parotitis*

10. PAROTID FISTULAE

(1) Definition

Parotid fistulae are abnormal communications between the duct or gland and the skin or interior of the mouth.

(2) Aetiology and pathology

External fistulae are caused by injury, ulceration or infection involving the parotid gland, its duct or branches, or they may arise secondarily to other local disease. Fistulae may follow operations upon the mastoid, temporo-mandibular joint, lymph glands or cheeks. *Duct or gland fistulae*

(3) Clinical picture

Saliva pours out through the fistula, and the discharge is aggravated during meals and by the sight of food. The external opening is usually of pin-point size and some degree of parotitis is commonly present (Fig. 248).

(4) Course and prognosis

Spontaneous healing does not occur.

Ptyalin
Sialography

FIG 248.—Healed parotid fistula. Showing scar at site of subcutaneous rupture of the left parotid duct during course of subacute parotitis.

(5) Diagnosis

The secretion should be examined for ptyalin. Sialography may help to determine whether or not a fistula is actually a parotid one, and, if it is, to determine the relationship between the fistulous opening and the duct system.

(6) Treatment

Treatment depends primarily upon the cause of the fistula, and upon whether or not there is an obstruction to the natural channel into the mouth. If the duct is blocked it is essential that this obstruction be overcome. If, however, the duct is patent, local treatment of the fistula itself may be successful. Fistulae of the main duct or its major branches present greater difficulties than those of the gland tissue proper.

Duct fistulae

Many operations have been devised for duct fistulae with the object of reconstituting the duct or of converting an external fistula into an internal fistula. At one time failure was frequent owing to infection, but penicillin should eliminate this risk. Parotid function should be depressed after all plastic procedures by bandaging the jaws, by limiting talking and by giving a bland fluid diet. The passage of probes along the duct may also be an important post-operative measure. The following is an outline of the treatment of fistulae in the various anatomical sites.

(*a*) *Buccal portion of duct*

A free exposure of the whole region is essential, and the best incision is that described on p. 434. The parotid duct must be exposed both in front of and behind the fistulous track, and localization may be helped by passing a probe from the mouth. The fistulous track must be excised and the gap in the parotid duct closed by 2 layers of fine ophthalmic catgut. The fascial tissues and subcutaneous fat must be closed carefully and both the main incision and the skin wound at the site of the excised track closed with horsehair. In cases in which the terminal part of the duct is obliterated or stenosed, it may be possible to convert the external fistula into an internal one. A similar free exposure is necessary, the fistulous track must be carried through the buccinator muscle, and the margins of the track sutured to the buccal mucosa.

(*b*) *Masseteric or intra-parotid ducts*

The exposure is similar to that for buccal fistulae and the treatment of masseteric fistulae is almost identical. When the fistula comes from a large duct within the substance of the parotid gland, it is necessary to suture the glandular tissue very carefully after the repair of the duct. The only satisfactory procedure when the distal part of the duct is obliterated or stenosed is a plastic operation in which a flap of buccal mucosa is brought through the buccinator muscle and the duct is reconstituted from this. Deep x-ray treatment is of value in diminishing secretion when operation is considered

inadvisable, either on account of the patient's age and general condition, or the local factors.

(c) Glandular

Parenchymatous tissue only is involved and not ducts of any appreciable size. Healing usually occurs after excision of the fistula, cauterization of the adjacent gland and careful wound closure. *Gland fistula*

11. ACUTE SUBMAXILLARY SIALODOCHITIS AND SIALO-ADENITIS

(1) Definition

This is an acute inflammation of the duct system of the submaxillary gland leading to infection of the gland tissue.

(2) Aetiology

Acute infection is invariably secondary to obstruction and is in most cases due to a calculus. Occasionally the obstruction results from a condition such as scarring of the duct or its vicinity.

(3) Pathology

The duct system rapidly becomes distended with infected saliva, and there is a great tendency for the infection to involve the cellular tissues of the floor of the mouth or the tissue planes of the neck. The submaxillary lymph nodes are involved and may suppurate. All acute infections are potentially serious *and may be one of the causes of Ludwig's angina.* *Ludwig's angina*

(4) Clinical picture

The patient comes under observation on account of a painful swelling in the submaxillary region and in the floor of the mouth, and a past history of obstructive submaxillary symptoms is usually present. Constitutional symptoms may be severe, and there is difficulty in opening the mouth and swallowing. The submaxillary region is enlarged and occupied by a tender, ill-defined swelling. If the obstruction is near the duct orifice there may be redness, swelling, and oedema in the line of the duct, but less change occurs if the obstruction is at the hilum of the gland. Local pressure may force pus through the duct orifice. *Buccal and submaxillary signs*

(5) Special aids to diagnosis

Radiographic examination should be carried out to determine the site and number of any calculi. Any pus should be examined bacteriologically. *Radiography*

(6) Differential diagnosis

Confusion may arise with dental infections of the mandible, alveolar abscesses, osteomyelitis, or with conditions leading to submaxillary lymphadenitis.

(7) Prognosis

All cases must be regarded as dangerous because of the risks of cellulitis and oedema of the glottis. In cases due to calculi, one attack predisposes to another. *Danger of cellulitis*

(8) Indications for surgical intervention

Operation is necessary when a calculus or stricture is situated in the anterior part of the duct, or on account of abscess formation in the submaxillary region (*see* Operative Technique of Submaxillary Calculi, p. 446).

12. CHRONIC SUBMAXILLARY SIALO-ADENITIS

(1) Definition

Chronic submaxillary sialo-adenitis or chronic submaxillary sialodochitis is a condition of chronic infection of the gland, associated with duct catarrh.

(2) Aetiology

Late sequel of calculi

The condition is a late stage of calculous obstruction and, less often, other types of obstruction or recurrent infection.

(3) Pathology

Replacement fibrosis

The gland preserves its shape but becomes hard. Histologically, there is fibrosis, round-cell infiltration and duct catarrh.

(4) Clinical picture

The patient comes under observation with a persistent submaxillary swelling. In calculous cases the earlier history is usually one of typical meal-time swelling. Examination reveals a visible, firm, slightly tender swelling, not attached to the skin and partially movable over the deeper tissues. Bidigital examination may reveal calculi within the gland or duct.

(5) Special aids to diagnosis

Radiographic examination should always be carried out.

(6) Differential diagnosis

Mixed or malignant tumours may cause confusion.

(7) Prognosis

Chronic infection gradually destroys glandular function. Acute infection may supervene if duct obstruction is present.

(8) Indications for surgical intervention

Excision of gland

The gland should be excised if there are calculi in the hilum or in the posterior part of the duct, in chronic enlargement and if a tumour is suspected.

13. SUBMAXILLARY CALCULI

(1) Aetiology

Comparison with rarity of parotid calculi

Submaxillary calculi (submaxillary sialolithiasis) are about 40 times commoner than calculi of the parotid. Bacteria are frequently present in the nuclei, but the part they play is probably by altering the reaction of the saliva. The frequency of submaxillary calculi is related to the high mucin content of submaxillary saliva.

(2) Structure and position of calculi

Size, number and shape

The calculus may be the size of a pin's head, and occasionally large numbers are present. The "date-stone" calculus is relatively uncommon. Multiple facetted calculi may occur in the gland or duct, while a large, rounded calculus or a branched calculus may develop at the hilum.

(3) Clinical picture

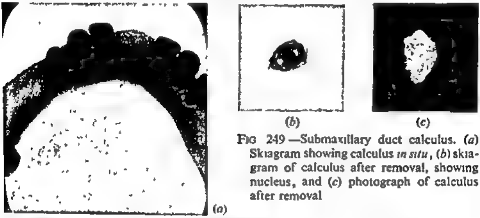
A patient with calculous disease may come under observation with any of the following conditions.

(1) Meal-time swelling of the gland, discomfort or pain.
(2) Persistent submaxillary swelling.
(3) Spontaneous discharge of calculus through duct orifice, or ulceration through duct.
(4) Presentation of calculus at duct orifice.
(5) Acute infection of the duct and gland.
(6) Acute infection and suppurative lymphadenitis.
(7) Ludwig's angina.
(8) Accidental discovery during x-ray examination.

It is usually possible to palpate calculi bidigitally, except in the presence of infection and oedema. Pus may be seen coming from the duct orifice.

(4) Special aids to diagnosis

Skiagrams should always be taken and must include intra-oral and extra-oral films (Figs. 249 and 250). A negative result does not necessarily exclude a calculus. *X-rays*



(a) (b) (c)

FIG 249—Submaxillary duct calculus. (a) Skiagram showing calculus *in situ*, (b) skiagram of calculus after removal, showing nucleus, and (c) photograph of calculus after removal

FIG 250—Large calculus in posterior third of the submaxillary duct.

(5) Differential diagnosis

Confusion is likely with dental conditions of the mandible, submaxillary lymphadenitis or submaxillary tumours.

(6) Prognosis

Risk of acute infection

A minute calculus may pass spontaneously. However, so long as a calculus is present there is always a risk of the development of acute infection.

(7) Indications for surgical intervention

Almost all cases require surgical treatment. A calculus may be a trivial condition, but it may lead to progressive obstruction, replacement fibrosis and inflammatory complications.

(8) Operative technique

(*a*) *Calculi in the anterior part of the duct*

Anaesthesia

Surface anaesthesia with 10 per cent cocaine may be adequate alone or may be combined with 1 per cent Novocain infiltration. Endotracheal anaesthesia is advisable for calculi which are not close to the duct orifice. A calculus wedged at the duct orifice should be treated by lifting up the region with dissecting forceps and excising the duct orifice obliquely, together with the calculus. A calculus in the anterior third of the duct should be removed after fixing the tissues behind the calculus.

(*b*) *Calculi in the hilum of the gland or in the posterior part of the duct*

Excision of gland

Difficulties of operation after infection

Penicillin

These must be treated by excision of the gland and of the posterior part of the duct. Care must be taken to secure the facial artery as it crosses the mandible, and also close to its origin, postero-inferior to the gland. If acute inflammation has occurred, the gland is fixed to its surroundings, and the dissection from the hyoglossus muscle and from the lingual and hyoglossal nerves may be difficult. The considerable cavity left between the tongue and the mandible must always be drained. Penicillin cover is indicated.

(*c*) *Cases with acute infection*

Treatment must be primarily directed to the infection. It is usually possible to remove a calculus in the anterior part of the duct and so release the infection. Such simple treatment is not possible when infection supervenes with a calculus in the gland or in the posterior part of the duct. Penicillin therapy may abort the infection and prevent suppuration, but an abscess may form in the lymph glands and may require drainage. Excision of the gland should be carried out after an interval of 2–3 months. Cases presenting with Ludwig's angina must be treated on the appropriate lines.

(9) Post-operative care

Stenosis after operations on the anterior part of the duct is unusual, but it may be advisable to pass a probe into the duct orifice occasionally during healing. In some cases of excision of the gland, branches of the facial nerve going to the lower lip are cut, but it may be possible to avoid them by keeping the incision well below the angle of the mandible. Some recovery of the lost movement usually takes place with time.

14. DISEASES OF THE SUBLINGUAL GLANDS

The sublingual glands may be involved in the following conditions.

(1) In acute infections the glands may be involved as part of an inflammatory process starting in connexion with the submaxillary duct or in Ludwig's angina.

(2) In recurrent and chronic infection, usually with involvement of all the large salivary glands.

(3) Calculi; these have been recorded in infants.

(4) Mikulicz's disease and Mikulicz's syndrome.

(5) Mixed tumours.

(6) Malignant disease.

(7) Ranula.

15. INNOCENT NON-EPITHELIAL TUMOURS

Lipomas of the parotid are extremely rare. They may be situated between the capsule and the gland, in the gland substance, between the gland and the pharynx, or the gland tissue may be replaced by fat. *Lipomas*

16 MIXED SALIVARY TUMOURS

(1) Definition

Mixed salivary tumours (mixed parotid tumours, endotheliomas or myxo-chondro-endotheliomas) form the most frequent type of salivary tumours, and they arise in any situation where salivary gland tissue exists.

(2) Aetiology

There is no relationship to mumps, bacterial parotitis or calculi The tumours usually start between 20 and 40 years of age, and the sexes are affected equally.

(3) Sites

The parotid is by far the commonest site, and growths here are about 10 times commoner than in the submaxillary gland. Tumours of the hard or soft palate form a small but important group. The less frequent sites include the upper lip, tonsil, ampulla of the parotid duct, floor of the mouth, sublingual gland, nasopharynx, pharynx, larynx and trachea, base of the tongue, and the auditory meatus. *Parotid* *Submaxillary* *Palate* *Less common sites*

(4) Morbid anatomy

The tumours vary in size from that of a pea to that of a human head in the cases described by the older writers. They are slightly lobulated and encapsuled, the fibrous capsule being adherent to the glandular tissue. The capsule may be incomplete, or may contain seedlings from which growth and lobulation take place. The tumours are firm or elastic, and on section have a potato-like appearance. Cystic degeneration or haemorrhagic infiltration may occur. *Capsule*

Histologically the tumours consist of the cellular elements and a myxomatous matrix. The epithelial cells are arranged in finger-like processes or acini. *Histology*

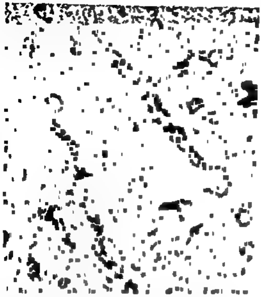


FIG 251.—Photomicrograph of mixed parotid tumour, showing characteristic arrangement of cells in irregular acini or tubules between which the epithelial elements are scantier and in a myxomatous matrix.

The myxomatous material is actually mucus secreted by the tumour cells (Fig. 251).

Origin

The tumours are derived from glandular epithelium and are certainly not "mixed" in the sense of being derived from more than one embryonic layer. Histological classification and grading are unsatisfactory.

Difficulties of classification

The only classification of value is that based on clinical, macroscopic, and microscopic features, and one which includes both benign and malignant types On this basis it is possible to record growths as benign, semi-malignant or malignant. Malignant tumours are described later in this article.

(5) Clinical features

Parotid tumours

Growth is slow and painless. Parotid tumours arise near the angle of the jaw and extend forwards or pass medially between the mandible and the mastoid process (Fig. 252). Large growths may interfere with the movements of the jaw and they may cause deafness by pressure on the meatus.

(a) (b)

FIG. 252 (a) and (b).—Mixed parotid tumour, left, from a man of 36 years of age The tumour had been present for 4 years and had steadily increased in size.

Physical examination

Physical examination reveals a visible, well-defined and slightly lobulated swelling. The overlying skin is not attached to the tumour which, however, as it lies deep to the parotid fascia, is not always freely movable. The consistency is firm and elastic or soft, but fluctuation is rare.

(6) Treatment

This should be carried out on the lines indicated for benign mixed tumours.

18. MALIGNANT DISEASE OF THE SALIVARY GLANDS

(1) Aetiology

Modes of origin

Owing to the pathological features of salivary tumours, malignant disease forms no very sharply defined group. First, it may develop in an old-standing mixed tumour after many years of slow growth. Secondly, a mixed tumour recurrence may become malignant. Thirdly, a semi-malignant tumour may eventually become definitely malignant. Finally, malignant disease may develop as a primary condition.

Primary growths

Malignant tumours have a much shorter history than benign ones; the average age incidence is slightly higher and growth is more rapid.

(2) Pathology

Spread to adjacent tissues

The gross anatomy is largely determined by the mode of origin. The growths invade the gland tissue, and parotid growths may spread to the lower jaw, skull, brain and skin. Metastases are less widespread than in most types of malignant disease. The regional glands are involved in about 20 per cent of cases, the lungs and pleura are the common sites of visceral deposits, but

Metastases

the osseous system is rarely involved. Metastases may show a tendency to encapsulation.

Histology

Malignant tumours may be of the mixed tumour type, basal-cell, papillary, cystic, adenocarcinomatous or of squamous-cell type.

Secondary growths

Secondary carcinoma may occur in any of the glands. Primary sarcomas occur as lympho-sarcomas or fibro-sarcomas, and behave as sarcomas and not as salivary tumours.

FIG. 253.—Malignant parotid tumour, left, showing facial paralysis. From a woman of 40 years of age, in whom the condition had been present for 3 years. Treatment by local excision and by irradiation had been carried out.

(3) Clinical features

Pain

Growth is much more rapid than in the case of innocent tumours. Pain is severe, especially with parotid tumours. In this situation, the

Facial palsy

tumours often cause facial palsy and, less often, deafness and interference with the movements of the jaw (Figs. 253 and 254). The tumours may be encapsuled or ill-defined, and in some instances multiple masses are present. They are often hard in

Physical signs

consistency. The other physical signs include some degree of fixation to the skin and deeper tissues and possibly ulceration, and local or other metastases. It may be difficult to distinguish between an innocent tumour

which is wedged between the mastoid process and the mandible and a malignant tumour with commencing local invasion.

Low radio-sensitivity

FIG 254.—Malignant parotid tumour, right Patient of 42 years of age. The condition started as a carcinoma of the right parotid duct.

19. TREATMENT OF SALIVARY TUMOURS

Treatment may be by means of surgery or a combination of surgery with irradiation. The indications for operation are the general principles of tumour treatment and the risks of malignancy in benign tumours. Radiotherapy has recently been increasingly used owing to the high recurrence rate following operation, but in view of the low radio-sensitivity of salivary tumours they should be extirpated surgically whenever possible. Pre-operative irradiation may toughen the tumour capsule and make excision easier and safer; it may possibly cure the tumour without operation and it may eliminate other non-salivary conditions. It is unusual for benign tumours to show appreciable diminution in size as the result of irradiation, but some infiltrating tumours are extremely radio-sensitive.

Pre-operative irradiation

(1) Problems of treatment

Each case must be approached individually in the light of the probable course of the untreated disease, the limitations of surgery in the particular region and the problems confronting radio-therapy. Expectant treatment may be justified in benign tumours occurring in later life, or when the rate of growth is slow.

(2) Operative technique

Exposure

The exposure of parotid tumours must always be adequate and Lilienthal's incision is suitable for many cases (*see* p. 434). An excellent exposure for tumours between the mastoid and the mandible is obtained by combining Lilienthal's incision with the lower part of a mastoid incision entering the main incision at right angles and just under cover of the lobule of the ear. The technique to be followed must then depend on the size of the tumour and its relationship to its surroundings. Sharp dissection through the adjacent parotid is often possible. Partial excision of the parotid has been increasingly advocated both for encapsuled tumours and for malignant ones after preliminary ligation of the external carotid artery. Total parotidectomy should be reserved for malignant cases. Submaxillary tumours demand excision of the whole gland, while the palatal ones are best treated by diathermy or excision.

Partial or complete parotidectomy

(3) Scheme of treatment

The following is a suggested scheme of treatment for the various types of case but, primarily, it deals with parotid growths. It must be remembered that the real value of pre-operative and post-operative irradiation of benign tumours is doubtful.

Type of growth		*Treatment*
Small and mobile	–	Preliminary irradiation Excision
Large and mobile	–	Preliminary irradiation Excision Post-operative irradiation
Small and fixed	–	Irradiation Operation if tumour becomes operable, probably radical in type
Large and fixed	–	Irradiation
Recurrent tumours	–	On the lines of the above treatment of primary tumours.

(4) Post-operative complications

These include facial nerve palsy, salivary fistulae, the auriculo-temporal syndrome and recurrence. Facial palsy is almost inevitable in a proportion of parotid cases. Fistulae occur only after operation on the parotid gland, and they are glandular in type and usually heal readily.

BIBLIOGRAPHY

Ahlbom, H. E. (1935). *Acta radiol., Stockh.*, Supp 23.
Apfeld, G. (1933) *Z Hals-Nas -u. Ohrenheilk.*, 35, 152.
Bassoe, P. (1932). *Med Clin N. Amer.*, 16, 405.
Beck, A. L. (1947). *Ann. Otol , etc , St Louis*, 56, 439, 722.
Benedict, E B., and Meigs, J V (1930) *Surg. Gynec Obstet.*, 51, 626.
Bérard, L., Creyssel, J., and Colson, P. (1930). *Lyon chir.*, 27, 285.
Blady, J. V., and Hocker, A F. (1938). *Surg. Gynec. Obstet.*, 67, 777.
Blair, V. P., and Padgett, E. C. (1923). *Arch. Surg., Chicago*, 7, 1.
Carmichael, R , Davie, T B , and Stewart, M. J (1935) *J. Path. Bact.*, 40, 601.
Chargin, L , and Rosenthal, T (1931). *Arch Derm. Syph., Chicago*, 24, 236
Cope, V. Z (1919) *Brit J. Surg.*, 7, 130.
Fitzwilliams, D C. L (1927) *Brit. J Surg.*, 14, 472.
Ford, F. R., and Woodhall, B. (1938) *Arch. Surg., Chicago*, 36, 480.
Fraser, A. (1918). *Surg Gynec. Obstet.*, 27, 19.
Frey, Lucie (1923) *Rev. neurol.*, 2, 97.
Fridberg, D (1931). *Dtsch Z Nervenheilk* , 121, 225.
Fry, R M (1927) *Brit J Surg.*, 15, 291.
Hart, J. T., and White, C. (1934). *Illinois med. J.*, 65, 355.
Harvey, W. F., Dawson, E. K., and Innes, J. R. M. (1938). *Edinb. med. J.*, 45, 275
Horbst, L. (1931). *Z. Hals-Nas -u. Ohrenheilk.*, 30, 151.
Houck, J. W. (1939) *Surgery*, 6, 550.
Hybbinette, S (1935) *Acta chir. scand.*, 77, 19.
Ivy, R. H., and Curtis, L. (1936). *Int J Orthod.*, 22, 179.
Kaminsky, S. D. (1929). *Dtsch. Z. Nervenheilk.*, 109, 296
Lemaitre, F., and Baudouin, E. (1934) *Ann. Oto-laryng.*, 774.
Lilienthal, H. (1917). *Amer. J. Surg.*, 31, 101.

McFarland, J. (1926). *Amer. J. med. Sci.*, **172**, 804.
— (1936). *Surg. Gynec. Obstet*, **63**, 457.
McKnight, H. A (1939). *Amer. J. Surg.*, **45**, 128
New, G. B , and Harper, F. R. (1931). *Surg. Gynec. Obstet.*, **53**, 456.
Norrish, R. E. (1935). *Brit. J. Surg.*, **23**, 188.
Patey, D. H. (1940). *Brit. J. Surg.*, **28**, 29.
Payne, R. T. (1931). *Brit J. Surg*, **19**, 142.
— (1933) *Lancet.*, **1**, 348.
— (1936) *Ibid.*, **1**, 655.
— (1937) *Ibid.*, **1**, 867.
— (1938). *Proc. R Soc. Med*, **31**, 398.
— (1940). *Brit. med. J.*, **1**, 287.
— (1940). *Lancet*, **1**, 634.
— (1944). *Brit. J. Radiol*, **17**, 3.
Pearson, R. S B. (1935) *Arch Dis. Childh*, **10**, 363.
Reischauer, F. (1931) *Ergebn. Chir. Orthop*, **24**, 1.
Rolleston, H. D., and Oliver, M. W. B. (1909). *Brit. med. J.*, **1**, 1296.
Schmieden, V., and Voss, O. (1931). *Dtsch. Z. Chir.*, **234**, 313.
Seifert, E. (1926). *Dtsch. Z. Chir.*, **198**, 387.
Smith, M. K. (1939). *Ann. Surg.*, **109**, 551.
Trioumphoff, A. (1926). *Pr. méd.*, **34**, 1350.
Vaughan, W. T. (1925). *J. Amer. med. Ass*, **84**, 583.
Warthin, A. S. (1929). *J. Cancer Res.*, **13**, 116.
Wilson, C. W. (1936) *Clin Sci.*, **2**, 273.
Wood, F. C (1904). *Ann. Surg.*, **39**, 57, 207.

[References to other titles are given under Salivary Glands in the Index Volume The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1938), Vol. 9, p 449.]

SCALP AND SKULL

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1. TRAUMATIC SWELLINGS

(1) Haematoma

299.] The subcutaneous haematoma is small, the margins are hard due to fibrinous deposit and the centre fluctuates, often making the diagnosis from depressed fracture difficult.

Subaponeurotic haematomas are usually diffuse and will pulsate if there is a fracture opening up the diploic channels, venous sinuses or meningeal vessels. They are occasionally associated with an extradural haematoma producing intracranial symptoms.

Sub-pericranial haematomas usually occur during labour. They are called cephalhaematomas and, owing to the attachment of the pericranium to the dura mater, are usually localized to a single bone of the cranium. These swellings are treated by aspiration.

(2) Aneurysms

True aneurysms of scalp vessels are rare. False aneurysms are due to injury to the vessel wall and are really pulsating haematomas over which the skin may ulcerate (Fig. 255).

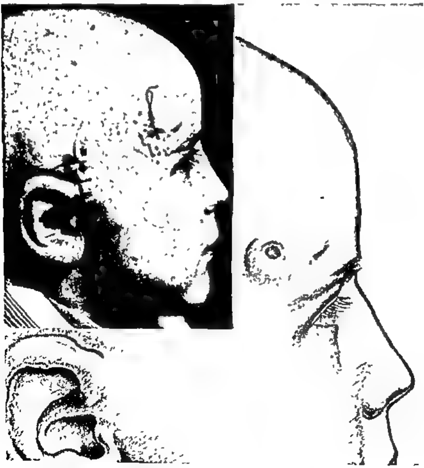


Fig 255.—Ruptured ulcerating aneurysm following penetrating wound, cured by division and ligation of the superficial temporal artery.

Pathology

Cirsoid aneurysm has been shown by angiography to be due to a fistulous communication between the arteries and veins of the scalp. It may be congenital or traumatic in origin (*see* Vol 2, p. 337). The walls of the arteries supplying the lesion are thickened and hypertrophied, but the main mass is due to large sinusoidal spaces in connexion with dilated veins. The pulsating compressible swelling extends widely, and may involve the whole scalp; there is a loud bruit; the surface may ulcerate and the patient may bleed to death (*see* Vol 2, Figs. 173 and 174).

Clinical state

Treatment of cirsoid aneurysm

In the past it has been regarded as highly dangerous to attempt to cure this condition. Now a preliminary angiography is performed to demonstrate the main vessels supplying the mass. These are transfixed and divided through short incisions at the margins of the involved scalp, though in exceptional cases one or both external carotids may have to be ligated. If all the vessels taking part in the anastomosis have been obliterated, the blood in the sinuses should thrombose in a few days. If not, then the injection of sclerosing fluid should be tried. When thrombosis and organization occurs the condition is cured.

(3) Pneumatocele

This is a subaponeurotic, irregularly lobulated, soft swelling, associated with a fracture into an air sinus.

(4) Meningocele (traumatic cephalhydrocele)

The spurious meningocele seen in children is a localized, circular, pulsating collection of cerebrospinal fluid, occurring in relation to a simple fissured fracture with a dural tear. To cure this condition the dura must be repaired.

FIG. 256.—Gummatous ulceration of forehead and cheek.

2. INFECTIONS

(1) Syphilitic infection

A gumma in the scalp gives rise to a tender, elastic, slightly elevated swelling. When it breaks down, a punched out, serpiginous ulcer with a wash-leather slough is produced (Fig. 256). The skull may be involved by gummatous infiltration, and caries results. The patient complains of severe nocturnal headache. Skiagrams show a fine moth-eaten porosis with sclerotic islands,

giving a characteristic worm-eaten appearance. Secondary infection may occur and cause complications.

(2) Tuberculous osteomyelitis

Tuberculous infection of the calvarium is rare. It occurs in children and young adults, who have a tuberculous infection elsewhere. In the skull the lesion is usually single, and may break down, forming a cold abscess. If erosion of the skin occurs the ulcer margins are undercut and blue.

(3) Pyogenic osteomyelitis

(a) Pathology

Infection of the skull bones results directly from without, through a wound, by continuity from an infected air sinus, or by way of the blood stream. *Mode of infection* Infection commences in the diploic channels. Granulation tissue and pus collects in the diploe and between the inner table and the dura, sometimes replacing both tables of the skull. The degree of sequestration varies, there may be very little with viable islands of osseous tissue adherent to the dura. When the outer table and pericranium are penetrated the extent of the sub-aponeurotic abscess is determined by the attachment of the aponeurosis. It may point anywhere in the scalp, but usually is over the affected bone.

(b) Clinical features

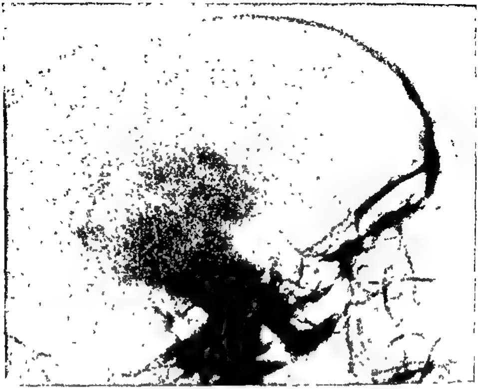
Infection of the skull may occur in a patient already suffering from an infected wound or air sinus, or from septicaemia; the patient then complains of headache and develops an area of local tenderness with fever. A boggy oedematous tender scalp swelling often develops, known as "Potts' puffy tumour" (Fig. 257).

Fig. 257.—Potts' puffy tumour—osteomyelitis of skull due to dart wound. Sinus can be seen in coronal suture line

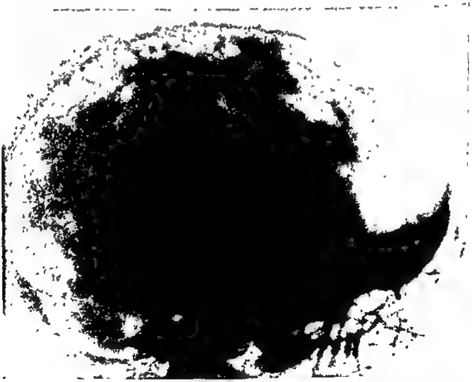
Complications In some cases thrombosis of dural vessels, or penetration of the dura, may give rise to a subdural empyema, which spreads over the cerebral hemispheres and the tentorium, or along the falx cerebri. This condition is ushered in by rigors, raised temperature and increased pulse rate. Delirium, drowsiness and slight neck rigidity may occur. Gradually both the headache and area of tenderness increase. This is followed by Jacksonian fits, paresis and aphasia, and coma which deepens; death occurs within 10–14 days. Other complications associated with osteomyelitis are meningitis and cerebral abscess, and those usual for sepsis, namely toxaemia, septicaemia and pyaemia.

(c) Investigation

Skiagrams are necessary to assess the extent of the infection; after the first 14 days a faint mottling is seen due to osteoporosis; later the definition is increased as the condition spreads by contiguity (Fig. 258) or by the diploic *Radiology*



(a)



(b)

FIG. 258.—Skiagrams illustrating (a) osteomyelitis in relation to frontal air sinus, and (b) spreading over the whole calvarium by direct contiguity. (Pre-penicillin era.) (*Reproduced by courtesy of Dr. J. L. Grout and Mr. Vincent Townrow.*)

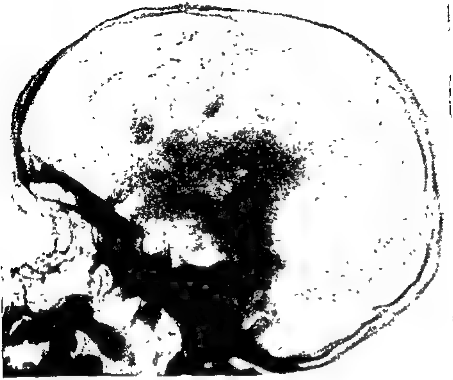


Fig. 259.—Skiagram showing osteomyelitic spread by diploic channels (same patient as in Fig 257).

Fig 260 —Skiagram showing sclerosis of occipito-parietal region in relation to a chronic extradural collection of pus. The condition had been present for 10 years, the skull wall was 1 inch thick.

channels (Fig. 259). In chronic localized cases there may be a rim of sclerosis round the rarefied area. If a sequestrum forms there is an irregularly shaped, dense shadow surrounded by a rarefied zone. Sclerosis of the bone occurs in chronic infection (Fig. 260).

Blood culture Blood counts and cultures should be taken in cases with a remittent temperature. *Lumbar puncture* Lumbar puncture is performed to exclude intracranial complication. A pressure above 220 millimetres of water is abnormal. The cerebrospinal fluid should be examined to exclude meningitis. *Exploratory puncture* If there are signs of cerebral [illegible]ement, exploratory burr holes or even ventriculograms should be made [illegible] either subdural or intracerebral pus. *Bacteri[illegible]* The causal organism should [illegible] if possible and the penicillin sensitivity investigated.

[illegible]atment

[illegible] pyogenic osteomyelitis should be treated on general lines and by [illegible]apy or systemic penicillin. By this means it may be possible to [illegible] infection. *Local* If a subpericranial abscess forms it should be aspirated [illegible]ic catheter inserted through a stab incision so that penicillin can [illegible] directly into the infected area. In favourable cases the lesion may [illegible] without further surgical intervention. *Exci[illegible]* If sequestra form, they should be [illegible]. There is no difficulty in recognizing the extent of the lesion both in [illegible] and by the distribution of the granulation tissue seen at operation [illegible] infecting organism is resistant to antibiotics and chemotherapy, then it must be dealt with by removal of all the affected bone.

Treatment of subdural pus [illegible]dural spread is suspected a burr hole is made at the Sylvian point behind the hair line. If pus is present it should be drained and a tube placed into the subdural space. Half a million units of penicillin should be instilled twice daily until the infection is controlled. (For treatment of Cerebral Abscess *see* Vol. 2, pp. 323–335.)

3. TUMOURS OF THE SCALP AND SKULL

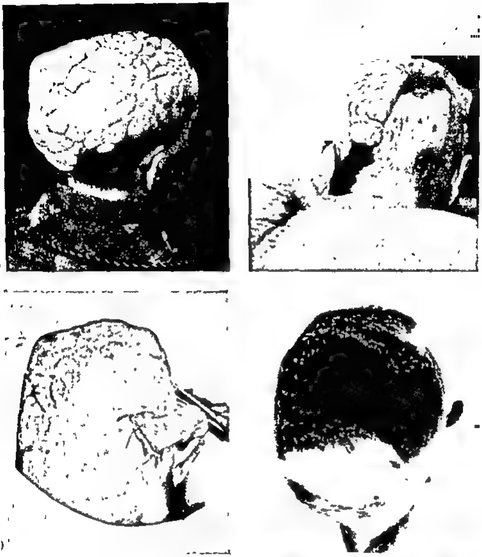
(1) Sebaceous cyst

A sebaceous cyst may become infected and rupture. If its lining proliferates, a "Cock's peculiar tumour" results. The only satisfactory treatment is excision, combined if necessary with skin grafting.

(2) Epithelioma adenoides cysticum

This rare condition is also named "turban tumour" but the term "epithelioma adenoides cysticum" best describes its histological structure. The tumour slowly extends during the course of years, ultimately covering a large part of the scalp, even hanging down over the face. Its surface is smooth with little or no hair, it is reddish in colour, and lobulated, with fairly deep clefts intervening (Fig. 261 (a)). If the covering epithelium ulcerates, the surface bleeds and when infected exudes a foul discharge.

Treatment If the tumour is extensive the whole scalp may have to be excised and skin grafted. It is preferable to remove these tumours before they have reached such extensive dimensions. This may have to be done with the patient sitting upright. It would seem desirable, especially if the excision has to be done in stages, to carry out planned plastic procedures at the same time that the tumour is removed, thereby ensuring a much more satisfactory cosmetic result (Fig. 261 (b), (c), (d) and (e)).



(a) (b) (c) (d)

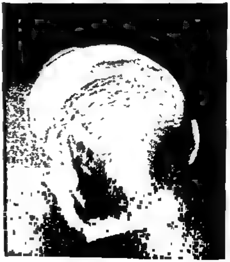


FIG. 261.—(a) Turban tumour 30 years' duration; (b) posterior quarter removed, area covered by advancement flap, (c) tubular graft behind the ear, (d) and (e) end-result.

(3) Epithelioma and rodent ulcer

The rodent ulcer is only locally malignant. An epithelioma metastasizes to regional lymph glands. In early cases excision is readily performed. Radiotherapy is also usually effective, but if not there should be no delay in excising the lesion. If the rodent ulcer has invaded the bone then wide excision of affected bone with plastic repair will be necessary. In cases of epithelioma if the lymph glands are enlarged and mobile they should be excised, if they are fixed radiotherapy is employed. When glands are not palpable the case, after operation, should be carefully watched.

(4) Dermoids

These occur at the bregma and inion. Dermoids vary in size, are spherical in shape, and are usually attached to the dura through a small skull defect. An intracranial dermoid may also occur between the skull and the lamellae of the falx cerebri. Its presence is indicated by a small sinus, about one inch below the inion, from which protrude a few hairs; a foul discharge may exude.

Treatment Such an intracranial dermoid is treated by removing the overlying bone, incising the wall and evacuating the contents, the epithelial lining should be destroyed with Zenker's fluid, which consists of:—

Pot. Bichrom. – – – –	25 g.
Hydrarg. Perchlor. – – –	50 g.
Sod. Sulph. – – – –	10 g.
Aqua dest. – – – –	1,000 ml.

Fifty millilitres of this fluid are mixed with 2·5 millilitres glacial acetic acid just before using.

A skin flap is turned into the cavity and sutured in position, thus the cavity is exteriorized and covered by skin.

(5) Epidermoids

Epidermoids may occur anywhere in the brain or skull. They cause pressure

Clinical state symptoms, for example, if in the petrous bone, a slowly developing facial palsy; if in the region of the external angular process, diplopia and proptosis They may also present anywhere in the calvarium as a fixed painless bony

Radiographic appearance swelling with egg-shell crackling. Radiologically there is a circular area of translucency with a well-defined margin, regular or scalloped, the centre of which may simulate sequestrum formation. The epidermoid contents should be

Treatment removed, the lining treated with Zenker's fluid and the bony defect repaired.

(6) Lipoma

Lipomas occur beneath the pericranium. They are flat hemispherical swellings, the margin of which can be rolled on the surface of the bone. To remove this tumour a curved incision should be made around the periphery of the swelling behind the hair line.

(7) Plexiform neurofibroma

Clinical state The plexiform neurofibromas are composed of a collection of lobulated, irregularly thickened nerve fibres and sheaths, surrounded by loose fibrous tissue. They are readily palpable beneath the skin which is usually thickened

and hangs down as a "pachydermatocele"; *this may* displace the ear and distort the outer canthus of the eye. When advanced the whole mass gravitates down over the side of the face like an apron; owing to the lobulation, the skin cannot be kept clean and often ulcerates. The eye may be involved by infection (Fig. 262). The condition is usually a part of a generalized von Recklinghausen's neurofibromatosis. *These lesions should* be excised and the mass of tangled nerves removed, together with the overlying pendulous scalp. *Treatment*

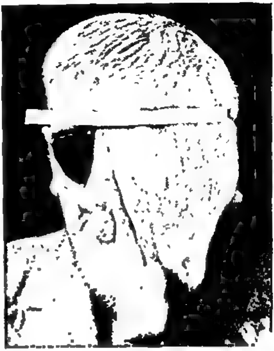


FIG 262.—Large pachydermatocele obliterating the features

(8) Lymphangioma

The lymphangioma may extend from the neck upwards to the face and forehead. The swelling is lobulated and translucent, it has an ill-defined edge, and infiltrates the scalp. This condition can be cured by excision provided that the overlying skin is sacrificed and is repaired by a split skin graft.

FIG. 263.—Sessile ivory osteoma of the mastoid region in a patient aged 40, it was first noticed when [illegible] years old.

(9) *Angioma*

Capillary naevi and cavernous angiomas occur on the face and scalp. They are sometimes associated with cerebral angiomas. Skiagrams may demonstrate calcification in the intracerebral vessels. Angiomas of the diploe present as small bony-hard swellings on any part of the calvarium. Skiagrams demonstrate a trabeculated area of translucency. These benign lesions can be left alone.

(10) Osteoma

In the skull, an osteoma is *Pathology* composed of compact bone. It is usually a flat sessile tumour but if left becomes an irregular lobulated projecting mass (Fig. 263). It may occur anywhere in the calvarium; the common sites of origin

are in the petrous bone and walls of the para-nasal air sinuses. The shape of osteomas of the frontal or ethmoid sinuses is determined by the disposition of the air sinuses, they may be attached to the skull by only a small base

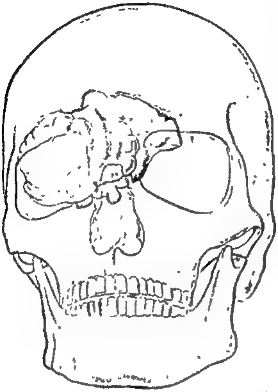
Complications

The bulk of the tumour is surrounded by distorted flakes of bone and mucosa from the flattened air sinuses (Fig. 264 (a)). (*See also* Vol. 2, Fig. 214.)

Frontal osteomas may enlarge downwards into the orbit displacing and destroying the eye (Fig. 264 (b), or bulge on to the forehead. They may ulcerate through the overlying skin, and if connected with the frontal sinus there is a periodic discharge of glairy fluid or, if infected, a thick creamy pus is discharged. If there is erosion into the nose and the underlying dura, cerebro-spinal rhinorrhoea with intracranial aerocele may arise, with the possibility of meningitis.

Treatment

The operative removal of these tumours is easily accomplished. A frontal scalp flap is reflected and if the tumour is arising from the lateral part of the frontal or from the ethmoidal bone a small frontal bone flap is made and the tumour removed after reflecting the dura from the bone After exposing the tumour, it



(*a*)

(*b*)

FIG. 264.—(*a*) An osteoma filling the frontal and ethmoidal air cells and right orbit. (*b*) A large bone flap which crossed the middle line was used to remove the osteoma Note the loss of the right eye.

may be possible to divide its point of attachment to the skull, thus leaving the orbital margin intact, otherwise this margin requires reconstruction. If the tumour is placed centrally it is more readily removed by perforating the anterior wall of the frontal sinus in the midline. The resulting bony defect will need to be repaired. If the tumour has eroded the dura, the opening must be carefully closed and reinforced by a piece of pericranium.

(11) *Osteochondroma*

This rare tumour arises at an early age in the cartilaginous anlage of the ethmoid. It may remain benign for years, but ultimately becomes an osteochondrosarcoma. The orbits and antra are pushed apart and the base of the nose and forehead become widened and displaced forward, thus cause a "frog-face" deformity. Surgical intervention is possible only in the early stages.

(12) Carcinoma

The calvarium or base of the skull may be involved by direct extension from a rodent ulcer, an epithelioma or a nasopharyngeal carcinoma. The diploe may be the site of blood-borne metastases from carcinoma of the thyroid, kidney, prostate, breast or bronchus. The lesions may be single or multiple, and osteolytic or osteoblastic in type. The only treatment is radiotherapy.

(13) Sarcoma

Sarcoma of the skull is described as either periosteal or medullary. The hyperostosing meningiomas have, however, caused confusion. A meningioma

FIG 265.—Skiagram showing perforation and disruption of skull wall by a sarcomatous meningioma—this patient succumbed 4 months after the tumour of the scalp was first seen.

can be mistaken for a sarcoma when the tumour perforates the overlying skull and invades the soft tissues (Fig. 265). Clinically a sarcoma is a rapidly growing, lobulated tumour varying in consistency. It may fungate through the scalp tissues. A sclerosing type of sarcomatous change may become superimposed on Paget's disease of the skull. Treatment is of no avail.

4. WOUNDS OF THE SCALP

(1) Clinical features

Types of wounds

Scalp wounds caused by the head striking the ground have irregular, jagged, stellate lacerations in a bruised and abraded area. If the head has been hit tangentially, the scalp will be more widely lacerated, and there will be greater separation in the subaponeurotic plane. Hair, dirt and foreign matter will be buried in the depths of the wound and the pericranium may be torn.

(2) Investigation

Radiography

All scalp wounds should be radiographed in order to establish the presence and site of any fracture. In forehead injuries special sinus radiographic studies should be made to detect dural penetration. (*See* Vol. 2, p. 372.)

(3) Operative technique

Anaesthesia

Unco-operative patients or those with extensive lacerations will require general anaesthesia, otherwise a local anaesthetic is sufficient. In the neighbourhood of the laceration the scalp must be shaved over a wide area. The wound edges are retracted and all foreign matter and devitalized tissue removed. If treated immediately after the injury it may be unnecessary to excise the skin edges, but all frayed tissue must be removed. Bleeding points are best controlled by forceps applied to the galea which is folded over the skin edge, or by diathermy; sulphonamide-penicillin powder is blown into the wound before suturing. All scalp wounds should be closed with two layers of silk sutures (*see* Vol. 2, Fig. 270). The deep layer is inserted to approximate the galea, this prevents any tension of the skin and prevents haematoma formation. The superficial layer of silk sutures is used to obtain accurate skin apposition and is removed after 48 hours. In cases of loss of pericranium or scalp tissue, the injured area should be covered without tension by a rotational flap, and the bare area of pericranium should be covered by a Thiersch graft. Infection is rare when early and careful wound toilet is performed together with the use of antibiotics and chemotherapy.

Preparation of Technique

Rotational flap

(4) Plastic repair of the scalp

This is necessary when a portion of the scalp has been lost by injury or operation. If the forehead is involved it should be covered by hairless skin, but on the remainder of the scalp hairy skin should be used. In males, a whole thickness skin graft may be applied to the top of the head, the hair-bearing skin being reserved for the back and sides; in this way the centrally placed bald patch will look more natural (Fig. 261 (d) and (e)).

If there has been a complete avulsion of the scalp and the pericranium is intact, a split skin graft should be applied. If any portion of the scalp remains attached it should be replaced, and time will determine if it is viable. If a large oval area of hair-bearing scalp has been lost, plastic operations by using the remainder will help considerably in obtaining a satisfactory cosmetic

appearance. These operations are carried out in stages. At the first operation a long incision is made from before backwards and parallel to the length of the avulsed area, on the side on which most scalp remains This incision terminates on the forehead just anterior to the hair line. The strip of scalp which may be 8-10 inches long and 2 inches wide is freed from the underlying pericranium, its anterior and posterior attachment being left to preserve the blood supply. It is then swung over the top of the head like a bucket handle. At a second operation vertical incisions are made downwards from the edge of the denuded area to behind the ears. These scalp flaps can then be reflected and used as rotational flaps. The strip of skin placed over the vertex at the previous operation can later be split down its centre and the two halves separated. In this way strips of hair-bearing scalp are separated by strips of granulation tissue (Fig. 266). If the intervening strips of granulation tissue are not too wide it is unnecessary to use Thiersch grafts, as these

FIG. 266 – (a) and (b) Partial avulsion of scalp; (c) and (d) bucket-handle flap over from left side

(e) (f) (h)

FIG 266 (*cont.*).—(*e*) and (*f*) plastic procedure utilizing skin from scalp aspect of ear; and (*g*) and (*h*) end-result.

areas will be epithelialized from the skin edges. If the denuded area is at the back of the head the remaining scalp and skin is separated well down on to the neck, care being taken to preserve the occipital artery which enters the flap about its centre. This area of scalp is then drawn well up on to the back of the head. When it is obvious that there will be insufficient tissue available to cover the denuded area a tubular skin graft should be brought up from the front of the chest.

Tubular graft

It may be impossible to carry out an adequate plastic repair in a case of third degree burns, as all soft tissues have been destroyed. If left the outer table of the exposed skull may necrose. Plastic repair of such an area may be attained by drilling numerous small holes into the exposed bone, through which granulation tissue will subsequently sprout from the diploe, and thus a bed for the skin graft is formed. In any plastic repair, the bacteriological flora in the granulation tissue should be investigated prior to operation.

Necrosed outer table of skull

Bacteriology

5. REPAIR OF SKULL DEFECTS

(1) Aetiology

The majority of skull defects are the result of the penetrating wounds of war, but they may also be caused by débridement of a depressed fracture, by the removal of sequestra, by marsupialization of an intracerebral abscess, or by excision of bone infiltrated by a neoplasm such as a meningioma (*see* Vol. 2, p. 381).

(2) Clinical state

The operative skull defects with intact dura appear to cause very little discomfort. The patients recovering from penetrating wounds complain of pains in the region of the scar, and of headaches, dizziness, faintness, irritability, poor memory and epilepsy. They worry about their appearance and the supposed dangerous possibilities of the defect. The tension of the pulsating area varies with posture and also with intracranial and atmospheric pressure. It is impossible to assess the cause of these complaints, but they cannot all be attributed to the skull defect. Penetrating wounds must be associated with varying degrees of local or generalized brain damage. The underlying brain is anchored to the margins of the defect by a meningo-cerebral cicatrix, and though some of the symptoms are due to pulsation of the brain and variation in atmospheric pressure, others are caused by a mild post-concussional syndrome, the degree of which varies according to the personality of the patient.

(3) Indication for repair

In spite of these considerations simple repair of a skull defect causes improvement of subjective symptoms, it abolishes some of the psychological factors, improves the appearance of the patient and lessens speech disabilities. Further benefit might be assured by separating the scar between the brain and the dura, thus reconstructing the subdural space, so that the injured brain again becomes capable of slight displacement on movement of the head. Amnion, tantalum foil and fibrin film have been used in an attempt to insulate the scars, but the mesodermal reaction around each makes this technically uncertain.

(4) Time of operation

If operation can be done within twelve hours, then after a meticulous wound toilet fragmented bone may be replaced without risk of infection. *Primary operation*

Before embarking on a secondary operation for the repair of a skull defect the fundamental principles of surgery must be observed. The overlying dermis must be healthy and free from extensive scarring, if there is a wide scar it may be possible to excise it and reconstruct the scalp at the time of the skull repair, but it is usually preferable to reconstruct the scalp as a preliminary measure. Pre-operatively all wounds should be given provocative massage and radiant heat in order to light up any latent infection. *Secondary operation*

In penetrating wounds which have healed by first intention, a plastic repair may be carried out within four months, but if there has been any evidence of wound infection it should not be undertaken until twelve months have elapsed. Failure to observe these rules may result in delayed infection and

ulceration of the skin, and the material used for the plastic repair may have to be removed. The dangers of infection are much greater when the frontal air sinus has been involved.

(5) Types of material

Only three materials for repairing defects will be mentioned, but many more have been tried.

(a) *Acrylic resin inlay*

Technique

This plastic Perspex-like material is transparent and radio-translucent. It is cast to the required shape by a dental mechanic, after taking an impression through the intact scalp or after exposing the defect at operation. Since the plate requires several hours to make, it may be necessary to insert it at a subsequent operation. It is fixed in position by suturing the edges to the pericranium.

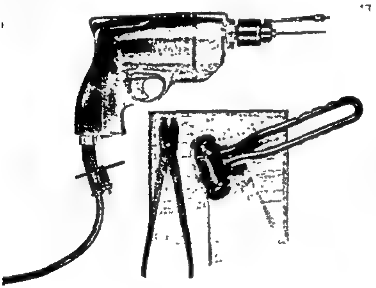


FIG. 267.—Block, cutters, hammer, tantalum sheet and drill for making hole in skull for tantalum screws, also reamer for countersinking.

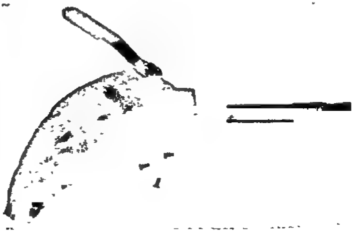


FIG 268 —Tantalum plate and punch for making holes for screw fixation.

(b) *Tantalum*

Technique

Tantalum is a biologically inert metal which can be cut and beaten to the required shape (Fig. 267). Holes are punched into its margin, and it is fixed to the bone by tantalum screws (Fig. 268). The heads of these are countersunk by

reaming a suitable hole into the skull. In the larger defects, the plate may be prepared by making a cast through the intact scalp and then building a model of the head and beating out the tantalum on it.

(c) *Bone grafting*

Bone for grafting can be taken from the iliac crest, ribs or adjoining outer table of skull. If the outer table of the skull is used a very large scalp flap is raised exposing the defect and a wide area of adjoining normal skull. The margins of the defect are exposed and a similar shaped portion of the outer table of the skull is separated with an osteotome, moved across and secured over the defect. *Technique*

(6) Choice of method

The advantage of autogenous bone is that once the repair has been made and the graft has taken, there is little likelihood of further trouble. Bone should certainly be used in the repair of the orbital margin or region of the frontal air sinus Skull defects with diameters of three inches can be repaired by the osteo-pericranial flap method but larger defects than these may necessitate obtaining bone from other regions, and the technical difficulties are thereby increased, acrylic resin or a preformed tantalum inlay can be used in cases with large defects, thus ensuring an accurate shape and fit (*see* Vol. 2, Figs. 197–200).

If it is necessary to sacrifice an area of bone during the removal of a meningioma, tantalum can be used immediately to close the defect. It is very important to ensure firm fixation of any inlay; riding or slipping of an ill-fitting plate may cause discomfort and ulceration of the overlying scalp. In spite of every precaution to obtain haemostasis blood clot collects at these operation sites and one or two aspirations may have to be performed before healing takes place

BIBLIOGRAPHY

Bailey, O T., Ingraham, F. D., Neuhauser, E. B D, and Cobb, C A, Jun (1947) *J. Neurosurg*, 4, 465

Bland-Sutton, J. (1922). *Tumours, Innocent and Malignant. Their Clinical Characters*

...*es and Practice*, Vol. 3 Ed by W. W Keen Philadelphia, Saunders

DeLarue, N C., Linell, E A., and McKenzie, K. G. (1944) *J Neurosurg.*, 1, 239.

Elkins, C W., and Cameron, J. E. (1946) *J. Neurosurg*, 3, 199.

Gabarro, P (1945) *Brit J Surg*, 33, 188

Gardner, W J (1945) ...

Hemberger, A J., ...

Ingraham, F. D., a ...

Kubik, C S, and Adams, R. D (1943). *Brain*, 66, 18.

Lane, S, and Webster, J E. (1947) *J Neurosurg*, 4, 526.

McWilliams, C. A (1917). "Traumata of the Scalp", in *A Treatise on Regional Surgery*, Vol. 1, p 1 Ed by John F. Binnie London; Lewis.

Mowlem R (1917) ...

...aley, D. H. (1942). *Brit J. Surg*, 29, 290

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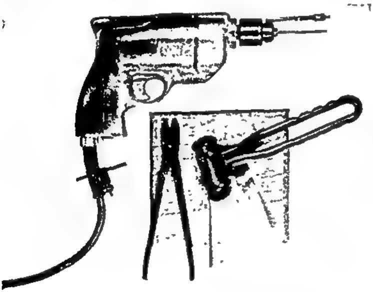

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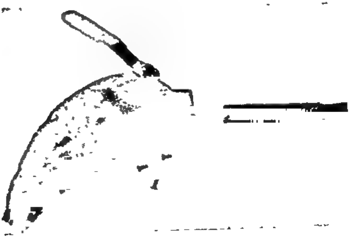

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BIBLIOGRAPHY

Bailey, O. T, Ingraham, F. D., Neuhauser, E. B. D., and Cobb, C A, Jun (1947). *J Neurosurg.*, 4, 465.

Bland-Sutton, J (1922). *Tumours, Innocent and Malignant. Their Clinical Characters and Appropriate Treatment*, 7th ed London; Cassell.

Bradford, F K, and Livingston, K. E. (1946). *J. Neurosurg*, 3, 318.

Cushing, H (1908) "Surgery of Head", in *Surgery, Its Principles and Practice*, Vol 3. Ed by W W. Keen. Philadelphia, Saunders.

DeLarue, N. C., Linell, E A., and McKenzie, K G (1944) *J. Neurosurg.*, 1, 239.

Elkins, C W, and Cameron, J. E. (1946) *J. Neurosurg*, 3, 199.

Gabarro, P (1945) *Brit J. Surg*, 33, 188

Gardner, W. J. (1945) *Surg. Gynec. Obstet*, 80, 303.

Hemberger, A. J., Whitcomb, B. B, and Woodhall, B (1945) *J. Neurosurg.*, 2, 2

Ingraham, F. D, and Bailey, O T. (1944) *J. Neurosurg.*, 1, 23.

Kubik, C. S, and Adams, R. D (1943) *Brain*, 66, 18.

Lane, S, and Webster, J E (1947). *J. Neurosurg*, 4, 526.

McWilliams, C A. (1917) "Traumata of the Scalp", in *A Treatise on Regi Surgery*, Vol. 1, p. 1 Ed. by John F. Binnie. London; Lewis.

Mowlem, R. (1947) *Ann R. Coll. Surg Eng*, 1, 143.

Pancoast, H. K., Pendergrass, E P., and Schaeffer, J. P. (1940) *The Head and* Springfield, Ill, Thomas.

Robertson, R. C. L. (1944). *J. Neurosurg.*, **1**, 227.
— and Peacher, W. G. (1945). *J. Neurosurg.*, **2**, 281.
Rowbotham, G. F. (1939). *Brit. J. Surg.*, **26**, 593.
— (1939). *Ibid*, **26**, 506.
— (1942). *Ibid*, **30**, 1.
Scott, M., and Wycis, H. T. (1946). *J. Neurosurg.*, **3**, 310.
Scudder, C. L. (1912). *Tumours of the Jaws.* Philadelphia; Saunders.
Small, J. M., and Graham, M. P. (1945). *Brit. J. Surg.*, **33**, 106.

[*References to other titles are given under Scalp and Skull in the Index Volume*]

SCHISTOSOMIASIS

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1. DEFINITION

300.] The blood-fluke parasite discovered at necropsy on a boy in Cairo by Bilharz in 1851 was termed *Bilharzia haematobia*, and the coincident disease, the brunt of which falls on the urinary bladder, is known as bilharziasis. During the present century, however, related parasites were proved responsible for kindred ailments, mainly of the gut; and since it happens that the leaf-like males fold lengthwise to include the slender female in a groove or cleft, the genus therefore gets the name of schistosoma (from *schistos*, cloven, *soma*, body). The larval stages of the three common species enter man successfully and pass their adult life within his veins. These species are: *Schistosoma haematobium*, or *Bilharzia haematobia* (Africa and neighbouring parts of Asia); Manson's schistosome (Africa and South America, chiefly); and *S. japonicum*, the Far East blood fluke (Fig. 269).

Three common blood flukes

The bovine fluke *S. bovis*, which also dwells in sheep, goats and baboons, is found as a rare parasite of man in Natal and the Belgian Congo, causing, like Manson's schistosome, intestinal symptoms. Of graver import is the fact that cats, dogs and cattle rank with men as final hosts, and thus as reser-

voirs—and as distributors—for *S. japonicum*. Monkeys in West Africa spread *S. mansoni.*

Another schistosome (*S. intercalatum*) has recently been found infesting children in the Belgian Congo. Its eggs have terminal spines and are thus like those of *S. haematobium* but it gives rise to intestinal symptoms similar to, though milder than, those due to *S. mansoni*.

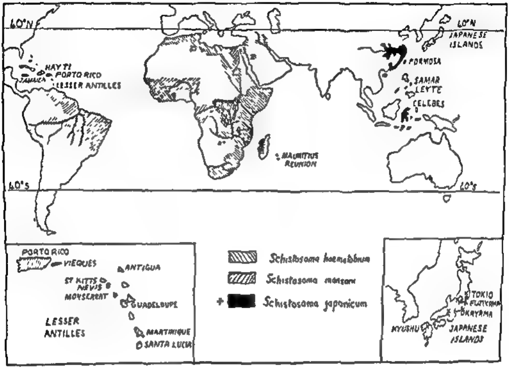


FIG 269 —Map showing regional distribution of schistosoma.

A knowledge of the life cycle of these flukes is vital to the study of the lesions they evoke in man; in the following pages, an attempt is made to correlate that cycle with pathology, and to place the clinical events of all the common infestations within a single sketch, made possible by the family resemblance.

2. THE LIFE CYCLE: PATHOLOGY AND *CLINICAL FINDINGS*

The blood flukes assume diverse shapes and pass the cycle of their lives in the alternate haunting of two hosts: they spend the obviously marital stage of their career in the veins of vertebrates; their seemingly asexual phase proceeds within selected kinds of water snail (for details, *see* Fig. 270). This

arval stages
Miracidia

larval phase begins when ciliated miracidia (*Meirakidion*, a little lad) hatch out in water from the eggs of schistosomes. Each miracidium behaves as though fastidious in choosing snails, and only when it meets the due affinity does it ... becomes

porocysts
ercariae

groups of elongated daughter sporocysts. The bloods ... these secondary sacs have tails to swim with, and so are called *cercariae*. A

single miracidium can thus beget some thousand fork-tailed "grandchildren" —cercariae that swim towards and pierce the moistened skin of any vertebrate within their range. But if by chance they meet a backboned creature alien to their full development they get no further than the skin and die before they reach a vein.

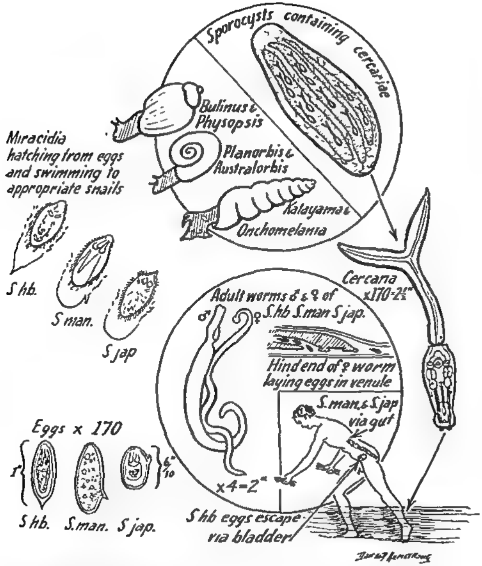


FIG 270—The life cycle of schistosomes. The circles enclose the phases that occur, respectively, in snail and human hosts. The "free" phases, outside the circles, subsist in water.

(1) The dermatitis of abortive invasion

A score of different cercariae are held responsible for bather's itch; their snail host, as a rule, is Lymnea, and some water-bird, perhaps, is their appointed vertebrate.

In Manitoba (Canada), and in certain parts of Michigan, in Malaya and once in Cardiff (Wales) this "dead end" infestation has produced a sharp but

Mode of infection

transitory scourge for bathers at the summer lake resorts. Cort (1928) finds that 10 minutes after immersion in water loaded with cercariae the patient feels a prickling, followed by a crop of urticarial blotches which flatten out in half an hour and leave macules. Within 24 hours itching grows intense and papules form (Fig. 271); in 48 hours the part will hurt and swell, the papules become pustules, and after 5 more days the trouble diminishes and disappears

FIG 271 —Bather's itch (*By courtesy of Professor D B McMullen*)

– unless the infestation has been gross or scratching causes sepsis. The rash has been mistaken for a poison-ivy dermatitis, but it does not spread like ivy rash and stays confined to the spot where cercariae have entered.

Prophylaxis

An oiled or greasy skin is said to favour penetration, while an immediate towelling, before the skin begins to dry, is sometimes prophylactic. Calamine lotion relieves the itch.

(2) Successful venous invasion

When the cercariae are such as find in man a due congenial host, their full development proceeds and this is the source of lesions which today inflict a blight of body and of mind on 20 million persons who exist in primitive conditions between latitudes 40 degrees North and 40 degrees South (Fig. 269). In most of the endemic haunts schistosomiasis is spreading notably; it also threatens virgin zones where favourable snails abound and only seem to lack the advent of a human carrier. It must be stressed that lesions caught while merely visiting endemic areas, say during foreign service, are often relatively slight and in this case they are curable by drugs if recognized. They thus contrast with gross organic damage due to lifelong inroads.

Invasions by these dangerous cerçariae, unlike the frustrate sort described above, are often mild in their immediate effect and either cause slight irritation for a day or two, or merely "sting" a seasoned victim. On piercing the skin they lose their tails and enter the veins. These tailless aftermaths (metacercariae) are swept on through the heart to the lung capillaries where, in arrest or passage, they are apt to cause pneumonic change; this is discernible in *S. japonicum* invasion by means of radiography and clinical examination. Circulating back through the heart and the arteries (where many die in unpropitious sites), survivors reach and settle in the portal veins. Here male and female grow mature and pair; alive or dead they are a source of toxin. *Metacercariae*

(a) Early toxaemia preceding egg excretion

Toxins are responsible for the malaise, anorexia, afternoon fever and sweats (mistaken sometimes for malaria) which, plus an urticaria, follow invasion by a month or more. Cough occurs with *S. japonicum*, and asthma with *S. haematobium*. (The local signs in the gut, or in the bladder, are not evinced till eggs are laid.) During the early toxic stage there is leucocytosis with 30–70 per cent eosinophilia.

Adult worms of *S. mansoni* and *S. japonicum* linger in the portal liver veins before descending to the mesenteric venules. That, perhaps, is why both spleen and liver suffer much, and from the first, from them, and less from inroads of *S. haematobium* the adults of which quickly trend towards the pelvic plexuses. The harm is done to the liver by toxins, ova and thrombosis; and so the liver may enlarge during the early toxic time or later. Ultimately, shrinking from cirrhosis occurs, with veins resembling "clay pipe-stems". Ascites follows the cirrhotic onset. Changes in size of the spleen are parallel but often not coincident; their cause is still debated. *Effects in liver and spleen*

(b) The part played by eggs

Each pregnant female lays a row of eggs along a venous terminal. An extra vein supply may thus condemn some special aspect of a tube like the urethra to bear the brunt of local infestation (*see* p. 478). Each ovum bears a single embryo and each has a spine which is terminal in *S. haematobium*, lateral and large in *S. mansoni*, lateral and tiny in *S. japonicum*. The favoured eggs, depending on their kind, pass from the veins towards the lumen either of the gut or of the urinary bladder. They move in virtue of the muscular contractions of the viscus, procuring room for progress by means of a lytic fluid diffusing from the embryo through openings in the shell. Those eggs that reach the lumen of the gut or bladder are voided after least delay—two months or more from the invasion date—in urine (*S. haematobium*), or with faeces (*S. mansoni* and *S. japonicum*). *Oviposition* *Transit and ordinary egress*

There is, however, an overlap, and more than 10 per cent of patients harbouring *S. haematobium* excrete its terminal-spined eggs not solely in the urine but in faeces too; while 1 per cent of those who harbour *S. mansoni* in the gut pass lateral-spined mansoni eggs in the urine (Khalil and Betache, 1930).

Eggs also find an egress, somewhat less direct than from the gut or bladder, through the walls of the ureters; rarely, from the kidneys, pancreas or gall-bladder; more rarely still from the epididymis, seminal vesicles or prostate. *Rarer routes of exit*

Incarceration

Thus multitudes of eggs may fail to reach a lumen, and will die incarcerated. Alive or dead they cause significant reaction.

Effects provoked by living eggs

While still alive within a tissue, the eggs change the tissue vascularity and stimulate the cells. First effects appear, through endoscopes, as patches like red velvet that evidence congestion of the gut or bladder, and it is they (according to the type of schistosome) that cause, when squeezed by muscular contraction, the early painless bleeding noticed at the end of micturition (*S haematobium*), or bloody streaks which mix with mucus on the surface of a stool (*S. mansoni* and *S. japonicum*). Early in the gut, but later in the bladder, depending somewhat on the presence of bacterial infection, contractions become painful, and then, in the gut, complete the picture of a schistosomal dysentery.

Granuloma
Tubercles
Papillomas

Meanwhile, successive crops of living eggs excite the tissue cells to form a type of granuloma that shows itself in every kind of schistosome affection (Plates IV and V). If these productions lie near mucous surfaces they show as tubercles or bulges; or they jut as papillomas—this stage, however, prevails in the intestine, while it is often skipped within the bladder, where other lesions tend to pass directly into ultimate fibrosis, the final phase of schistosomal lesions. Through poverty of blood supply these granulomas at times degenerate and, if there is acute infection, the ulcer which ensues may eat its way so deeply as to reach a second surface and inaugurate a fistula—between, say, bladder and intestine, or linking either viscus with the skin. Then, too, infection, by contact or through the blood, will often start an abscess in a group of granulomas and so produce an ulcer, a sinus or a fistula.

Urethral and penile lesions

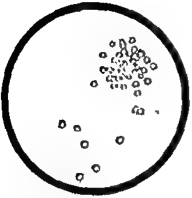
Papilloma is not formed in the urethra except where it finds free space—at the navicular fossa (Ali Pasha Ibrahim, 1928). Urethral ulcers form from septic plaques; and fistulae from these ulcers, in company with blocks of tortuous and lengthy stricture, are frequent in the bulbar portion. Because of venous distribution they start upon its dorsal face. Thence, from a single opening, they track to several openings in the perineal skin. Less commonly a penile fistula, immediately in front of the scrotum, goes straight to skin from the urethral floor.

Fibrosis and infection sometimes lead to schistosomal "elephantiasis" of the penis; the organ then is prominent and is never buried in the scrotum as [illegible] urethra (Makar, 1935) [illegible] mospermia.

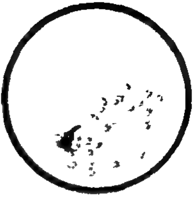
Reactions to dead ova

When ova die within the tissues, the type of cell [illegible] alters and fibrosis overtakes the older granulomas. Dead ova calcify, producing, when in bulk, two diagnostic signs: (1) those eggs that die *en masse* immediately beneath mucosal surfaces cause desquamation of the surface cells the place of which is taken by a trellis of translucent fibres. Through this imperfect screen the eggs appear like brownish sand—the famous "sandy patches". The number, size and confluence of these depend directly on the grade of infestation. They can be viewed with the endoscope or at necropsy. Within the bladder they show first at ureteric openings. (2) Incarcerated eggs that calcify in bulk (plus the fibrosis they induce) will often yield enough opacity to outline ureters or bladder on x-ray films (Fig. 272).

Fibrosis, due perhaps to toxins from dead eggs, sometimes of large gut but chiefly in the urinary bladder, restricts distension or may even cramp the



(a)



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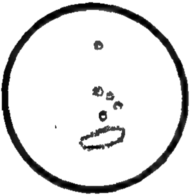

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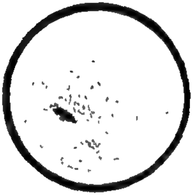

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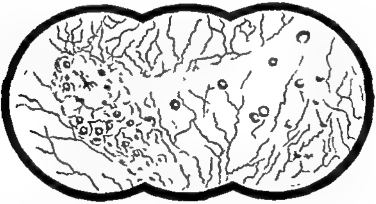


(e)

(*a*) Bilharzial granulations or tubercles (*b*) Bilharzial nodules The ureteric orifice is deformed, the surrounding mucous membrane of the bladder is anaemic and has a greyish-yellow colour (*c*) Bilharzial tubercles, some of them have fused to form bilharzial membrane which is surrounded by a hyperaemic zone. (*d*) Right ureteric orifice with "sandy patches" above it and fused granules forming a membrane below. (*e*) Bilharzial disease of the bladder before treatment. (*By courtesy of Professor N Makar, and Brit J Surg*)

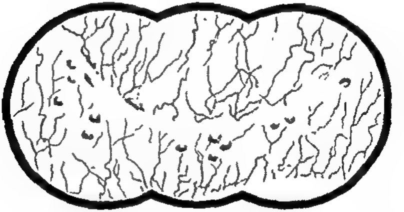
PLATE IV

(*a*)

(*b*)

(*c*)

(*d*)



(*e*)

(a) To the left of the figure there is a bilharzial ulcer, exposed by the disappearance of a pre-existing membrane Surrounding it are bilharzial tubercles. To the right an ulcer, well on the way to healing, can be seen in a saccule (*b*) Submucous bilharzial mass covered with bilharzial tubercles. (*c*) On the left is a septic ulcer. On the right is a large submucous mass covered with bilharzial tubercles. The rest of the vesical mucous membrane shows signs of inflammation. (*d*) Bilharzial papillomas (*e*) Bilharzial disease of the bladder one month after treatment with antimony sodium tartrate. The yellow nodules are the dead ova working their way through into the bladder cavity They do not indicate active bilharzial disease (*B*) *courtesy of Professor N Makar, and Brit J. Surg.*)

PLATE V

lumen, till the bladder holds only ■ drachm or two of urine. Fibrosis, on the other hand, bars fresh invasion by the eggs.

The ureters

The lower ends of the ureters may sometimes be the only site of bilharziasis, of which the early stage is either symptom-free or is marked by mild attacks of colic and the passage of small clots in company with eggs in acid urine. Ulceration soon brings pus; the urine becomes alkaline and the ureteric orifices gape. Later, with fibrosis, low-placed strictures (often an inch long, left and right) shut down and cause bilateral hydronephrosis of varying degree which may dilate the ureters to look like small intestine; and, frequently, infection starts and spreads to bladder and to kidney.

FIG. 272.—Bladder and ureters (the left with 2 stones) outlined by schistosome infestation. (*By courtesy of Professor Fahmy el Minyawi Pasha*)

(c) *Calculi, uraemia and anuria*

Stone follows in the wake of *S. haematobium*. A core of oxalate may crystallize round eggs or cell detritus; then, if infection turns the urine alkaline, phosphatic layers coat the core. The calculi in ureters lie often like a rosary behind the strictures; and sometimes with the stones—or in their absence—anuria occurs. *Anuria*

Defective function of the kidney, tolerated over years but trending to a terminal uraemia, governs the outlook and the surgery of every case infected with bilharzia. *Decisive role of renal function*

3. DIAGNOSIS

Uncertain cases from endemic zones are suspect till proved negative. In every case the diagnosis is confirmed by finding eggs in urine, in faeces or sometimes at biopsy. From heavily infected urine eggs are obtained in muco-pus that quickly settles out; if eggs are scarce the urine must be centrifuged. On the faeces evidence of *S. mansoni* or *S. japonicum* is to be sought in surface flecks of blood or mucus. When these are negative, the swabbing of mucosa through ■ proctoscope or by rubbing with a finger-stall—coated, not with Vaseline but with soap (Khalil and Betache, 1930)—will often bring back unspoilt eggs. Girges (1934) suggested that an absence of *S. mansoni* eggs was compatible with gross infestation whenever female worms were greatly outnumbered by males, and mouse experiments by Mayer and Pifano (1942) showed that this egg defect accompanies the marked preponderance of adult worms of either sex.

(1) Sedimentation method of finding eggs

Tests in special cases

The sedimentation method of finding eggs in light infestations of the gut is as follows. Using a conical 16-ounce glass measure, mix the faecal specimen with 10 times its volume of tap water. After 2 hours, siphon off the top two-thirds; fill up the measure with water, and mix. Repeat, until the supernatant fluid clears. Examine the remaining sediment for eggs with a ⅛-inch objective.

(2) Fairley's fixation test

This test is useful (1) early, before eggs appear; and (2) in late cases when eggs are incarcerated and cease to be excreted, for example in many splenomegalies of schistosomal origin.

The test is like the Wassermann, excepting that the antigen consists of extracts made with alcohol from snails infested by *S. haematobium* or *S. mansoni*. Results are positive with either antigen in those who harbour either worm. Reciprocal reaction with *S. japonicum* is still *sub judice*.

(3) The Alves skin test

This very delicate reaction—positive in every patient who is passing ova, but also positive in 30 per cent of egg-free persons from endemic zones—awaits precise assessment.

Technique of the Alves test

This test is made in the following way. Cleanse by filtration through fine muslin the ounce or so of water into which a single infested snail (*Physopsis*) is allowed to shed its 10,000-odd cercariae. From this clean filtrate strain off the cercariae on a piece of fine filter paper. Dry the paper at 65°–75° F., and cut it into bits. Extract these bits with 5 millilitres of one per cent phenol saline solution for 24 hours. Pass the extract through a Seitz filter and dilute it with an equal volume of sterile normal saline solution. Inject 0·01 millilitre of the diluted extract intradermally, using a tuberculin-type syringe and a fine-bore short bevelled needle. The sign of a positive reaction is the formation of a raised disc-like weal, often increasing nine-fold the size of the small original weal made by the injection, and sometimes pushing out processes like pseudopodia. This sign should appear in from 15 to 20 minutes. By that time the original weal will have disappeared in a negative reactor (Alves and Blair, 1946b).

4. TREATMENT BY DRUGS

Tartar emetic

Antimony kills blood flukes and is used most widely, and most cheaply, as tartar emetic (antimony potassium tartrate) injected into the veins. There must be no leak, as the drug corrodes the tissues. But, even after skilled injection, vomiting, cough or fainting may supervene directly, and later, in the night, "rheumatic" pains may occur. Brandy by mouth, with 1-millilitre doses of adrenaline and pituitrin intramuscularly, relieve immediate symptoms of intolerance. The frequency of these symptoms explains the use of other antimonial compounds.

Fouadin (stibophen)

Fouadin (stibophen), also called Neoantimosan, is popular because it can be used for intramuscular injection, but it is weaker in antimony content; patients, therefore, may require second courses. Some groups of children have lost weight when treated with stibophen; others have local pain,

nd Cawston (1943) favours for a child the lithium-antimony drug called *Anthiomaline*
.nthiomaline.

Alves and Blair (1946a) use antimony sodium tartrate intravenously for itensive dosage, thus greatly reducing the number of injections and the time f treatment—two cuts which are of capital importance, especially when ealing with a bulk of populace whose zeal for public health has not evolved.)angerous reactions did not appear in their 100 cases, and they found that f 48 who were followed up none passed eggs and 45 were negative to Alves's elicate test (*see* p. 480), after three months.

All dosages of the drugs will be found in the following schedule.

Schedule of dosage

(*a*) *Tartar emetic*

Tartar emetic (antimony potassium tartrate) is dissolved in a 6 per cent olution in distilled water. Each millilitre contains 0·06 gramme (1 grain) of he drug and 0·0198 gramme of antimony. Injections are given intravenously.

Tartar emetic, first used by Christopherson for schistosomiasis, is still the lrug most frequently employed. The following table of dosage is a modificaion of Day's scheme adopted by the Egyptian Government.

DOSES OF TARTAR EMETIC COURSE
(ACCORDING TO WEIGHT OF PATIENTS)

Males					Females				
Weight in kg	1st injection in ml	2nd injection in ml.	3rd injection in ml.	4th–12th injection in ml.	Weight in kg.	1st injection in ml	2nd injection in ml	3rd injection in ml.	4th–12th injection in ml
20–25	0·25	0·25	0·5	0·5	20–25	0·25	0·25	0·25	0·25
25–30	0·25	0·50	0·75	0·75	25–30	0·25	0·50	0·50	0·50
30–35	0·25	0·50	0·75	0·75	30–35	0·25	0·50	0·75	0·75
35–40	0·5	1·0	1·25	1·25	35–40	0·25	0·5	1·0	1·0
40–50	0·5	1·0	1·5	1·5	40–50	0·5	1·0	1·25	1·25
50–60	1·0	1·5	1·75	1·75	50–60	0·5	1·0	1·5	1·5
From 60 upwards	1·0	1·5	2·0	2·0	From 60 upwards	0·5	1·0	1·5	1·5

The total dosage of antimony per kilogram of body-weight averages 0·006 gramme for males and 0·0049 gramme for females.

Injections are given on alternate days.

(*b*) *Stibophen*

Stibophen (Fouadin) is used for intramuscular injection in a 6·3 per cent solution. The hydrated compound contains 13·5 per cent of antimony. One millilitre of the solution contains 0·0055 gramme. For a man of 60 kilograms (132 pounds) 1·5 millilitres are given on the first day of treatment, 3·5 millilitres on the second day, and 5 millilitres on the third and alternate days to the fifteenth day. Two further injections of 5 millilitres are given should eggs be present after the fifteenth day.

This represents a total dosage of antimony per kilogram of body-weight of 0·0036 gramme.

Early reports claimed 97·6 per cent of cures with this dosage (Khalil and Betache, 1930). In 1934 the cures in a fourth series fell to 53 per cent. Mills, using a more intensive dosage, gave a total dose of about 0 42 gramme of antimony in ten injections of stibophen over a period of 14 days to men of from 44 to 70 kilograms—a dose varying from 0 0097 to 0 006 gramme of antimony per kilogram of body-weight.

(c) *Anthiomaline*

Anthiomaline (lithium antimony-thiomalate) is used in a 6 per cent solution. Each millilitre contains 0 06 gramme (1 grain) of the drug and 0 01 gramme of antimony. Cawston (1943) states that a child aged 9 years can tolerate a total dosage of up to 40 millilitres provided that small doses (1·5–2 millilitres) be given on each of the first 7 days of treatment. Dosage can then be raised to 3 millilitres given in 8 doses during 14 days. These larger doses are with advantage divided between two sites of injection. Dosage of Anthiomaline still requires definitive assessment in terms of body-weight.

It has been found that doses of stibophen and Anthiomaline which either fall much below the maximum or are spaced over too long periods fail to kill schistosomes. The recent tendency therefore is to approach maximal dosage and to reduce the duration of treatment. Hepatic and, more especially, renal deficiencies—since it is the kidney that excretes antimony—probably account for most of the fatalities which are reported from the use of stibophen. No reports of deaths from Anthiomaline are available, but Ashkar states that it is more toxic than stibophen.

(d) *Antimony sodium tartrate*

Antimony sodium tartrate is used for intensive treatment in the method described by Alves and Blair (1946a). This is based on the fact that certain toxic substances show scarcely any toxic effect if injected very slowly. Antimony sodium tartrate is injected intravenously in a 6 per cent glucose-saline solution. One millilitre contains 0 06 gramme (1 grain) of the drug and 0 237 gramme of antimony. The total dosage of antimony per kilogram of body-weight is 0 0047 gramme. Six injections are given in two successive days. The total dosage of antimony sodium tartrate is calculated as 1 grain for each 12 pounds of body-weight as follows:

ANTIMONY SODIUM TARTRATE DOSAGE

WEIGHT OF PATIENT (IN POUNDS)	DOSAGE IN GRAINS						
	FIRST DAY			SECOND DAY			TOTAL DOSAGE
	9 a.m.	noon	3 p m	9 a m.	noon	3 p m.	
120	2	2	1	2	2	1	10
162	2	2	2½	2½	2½	2	13½

Each millilitre containing 1 grain of antimony sodium tartrate is made up with 5 per cent glucose-saline solution to 10 millilitres. *This volume can be*

injected slowly, in the minimum time of 5 minutes. Three-quarters of the total quantity of antimony sodium tartrate injected in this way is retained in the tissues for over 3 days. Its continued presence in relative bulk is thought to explain the good effects of the treatment.

The safety of the method in the presence of renal insufficiency has yet to be proved.

5. OPERATIVE TREATMENT

(1) Splenomegaly and splenectomy

After wide experience Stiven (1929) believes that the unoperated schistosomal victim with a splenomegaly survives its presence for about 3 years. No sure statistical study has yet been possible, but many patients are alive and working hard 10 years or more after splenectomy. In Egypt, the mortality from operation in skilful hands has long been roughly 10 per cent; pneumonia is the common cause of death. After splenectomy, pneumonia often follows lung collapse due to a flaccid diaphragm, no longer stretched upon a bulk of spleen. This high, apparently definitive, mortality suggested the use of a balloon to fill the empty spleen bed at the close of operation; its slow collapse gives leisure to the diaphragm for readjustment and seems to promise well. Pre-operative and post-operative breathing exercise is used with current methods to prevent pneumonia; anaemia, too, must be decisively corrected before splenectomy. Antimony, although it does not check enlargement of the spleen, should be employed to kill infesting schistosomes, and any other parasites are dealt with. The general condition of the patient, together with laboratory findings, and not the presence or absence of ascites, decides the date for intervention.

Mortality rate of operation

(2) Urethral fistulae and bulbar stricture

The cure of urethral fistulae and bulbar stricture demands in general a two-stage operation: (1) cystostomy diverts the urine from the field of operation; (2) when the operative field is disinfected the passage of a large bougie from the external meatus negotiates infallibly the multiple constrictions of the longest block—provided the precaution first be taken of cutting lengthwise through the perineum to the stricture but not into it. Then, with the block grasped firmly in the wound, the fingers make the tip of the bougie engage the stricture, and this they work along the stem of the advancing instrument (Hayden, 1925). These strictures never compromise the whole circumference of the mucosa The surgeon, therefore, helped by the bougie, resects them totally together with the fistulae, while he most carefully preserves the relic of mucosal continuity. If that is done, and if the bladder is kept clean, the tube regenerates and then may only need some intermittent dilatation to save it from extrinsic fibrous pressure.

The penile fistula seems simple by comparison with bulbar types, but it is discouraging to treat, though plastic operations will succeed, if surgeon and patient persist.

Penile fistula

(3) Ureteral stones and strictures

The early, low-placed strictures of bilharzia can often be dilated through a cystoscope. When they are old, an inch long and tough, accompanied or not

Late lesions

by stones, the fact that they are frequently bilateral makes it convenien approach both ureters through one incision. The midline hypogastric peritoneal route is therefore useful. The *peri-umbilical extension* gives n room and allows a clean separation of the two recti at the navel—where part (Fig. 273 (a)). By this route, when we detach and raise the peritone *the ureter is opened lengthwise*, not too close above the stricture; the st are removed and special care is taken that none slip upward. Then, passi bougie *into the open lumen* of the ureter, the surgeon grasps the elong *stricture with the other hand* and works the fibrous block along the sten the advancing instrument, *persisting till he feels* the metal tip move fr

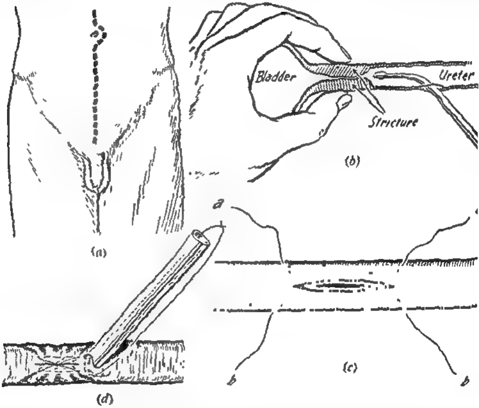


FIG. 273 —Extraperitoneal exposure of both ureters: (*a*) incision; (*b*) method of worki stricture over bougie; (*c*) closure of ureter: ends a, a, are tied with ends b, b, as or ligature; (*d*) ureter closed and drainage tube in place on third suture

in the lumen of the bladder (Fig. 273 (b)). The ureter is closed by passing suture lengthwise along each side of the incision. A tube is slid down on limb of a third suture, which can be left as a drain after the tube is withdraw (Fig. 273 (c) and (d)) With thorough dilatation and careful drainage thes gravely strictured ureters stay open for long periods.

The difficult case

In certain cases that are troublesome the back wall of the peritoneum stick firmly to the front of a low stricture; so, when the peritoneum is raised, the ureter, *instead of lying bare*, may still remain behind a pouch of peritoneal cavity—through which the *surgeon* is obliged to work. It follows that the site of the ureteral incision must afterwards be fixed for drainage to the front wall of the pouch.

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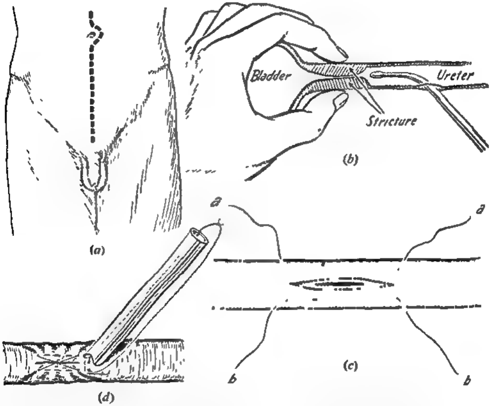

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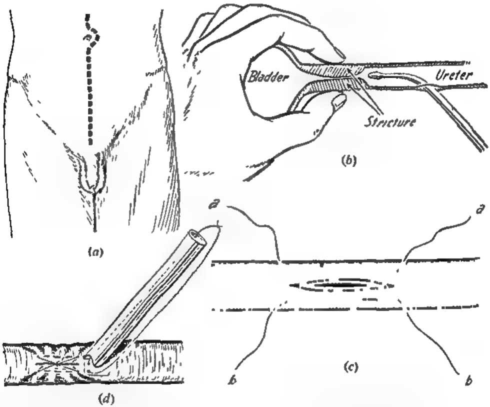

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(4) The kidney

The renal surgery of bilharziasis is that of stone, hydronephrosis, pyonephrosis and anuria. When x-ray examination shows no stone in the bilharzial anuric patient in whom a catheter has failed to travel up the ureters, and neither history nor examination indicates the "better" kidney, the midline suprapubic route allows the finding of a pair of strictured ureters and clears the way to each for ■ decision on dilatation and drainage.

(5) Schistosomal dysentery and large-gut surgery

Papillomas within the reach of an endoscope can be destroyed in stages by diathermy, and early dysentery responds to antimonial drugs.

(a) *Caecostomy and ileostomy*

The "wretched plight", however, of the patients with late or chronic disease has until recently seemed hopeless. Yet in the cases due to *S. mansoni*, a measure of relief can sometimes be obtained by irrigating through a caecostomy. Rankin (1926), however, is convinced that the colon has more rest with an ileostomy; and Smyly (1930), using this, cured very chronic dysenteric cases (due to bacilli, not to schistosomes) with 4-hourly half-pint washes of Dakin's solution in rising strength. *Relief through irrigation*

Dunlop (1946), from grim experience with drug-resisting dysentery in Thailand jungles, found the advantages of ileostomy "arresting". A small muscle-splitting opening (right rectus or MacBurney incision) allowed him to divide the ileum completely, 18 inches from the ileocaecal junction, and fix, seal off and intubate both "barrels" of the stoma. Three things required special after-care: (1) emptying the ileostomy bottle—5 times in 24 hours; (2) water replacement for the fluid lost; and (3) the fact that diets with much residue provoke a mild obstruction in a conduit which remains oedematous for some weeks after operation.

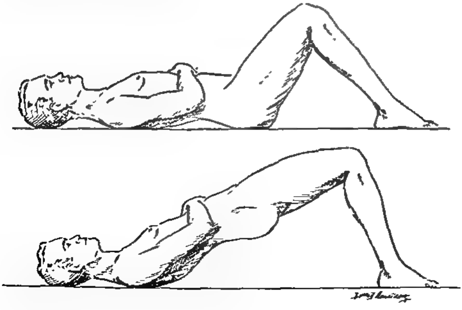

FIG. 274 —Exercise for strengthening perineal and levator muscles. The patient breathes out as he rises and in as he sinks. (*By courtesy of Dr. J. E. O'Loghlen*)

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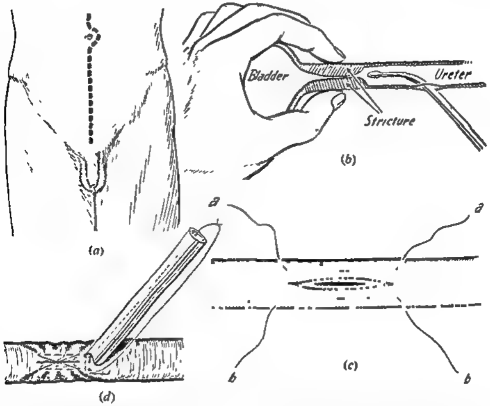

FIG. 273.—Extraperitoneal exposure of both ureters: (*a*) incision; (*b*) method of working stricture over bougie, (*c*) closure of ureter ends a, a, are tied with ends b, b, as one ligature; (*d*) ureter closed and drainage tube in place on third suture.

in the lumen of the bladder (Fig. 273 (b)). The ureter is closed by passing a suture lengthwise along each side of the incision. A tube is slid down one limb of a third suture, which can be left as a drain after the tube is withdrawn (Fig. 273 (c) and (d)). With thorough dilatation and careful drainage these gravely strictured ureters stay open for long periods.

difficult In certain cases that are troublesome the back wall of the peritoneum sticks firmly to the front of a low stricture; so, when the peritoneum is raised, the ureter, instead of lying bare, may still remain behind a pouch of peritoneal cavity—through which the surgeon is obliged to work. It follows that the site of the ureteral incision must afterwards be fixed for drainage to the front wall of the pouch.

front wall of a rectum which suffers full prolapse will then bulge in a gap between the disjoined edges of the two levator ani muscles. Sutures fasten the rectum to these edges and close the gap. The origin of the anal sphincter from the central point is then reconstituted by the transverse line of suture. In posterior fixation of the rectum removal of the coccyx leaves a window through which to sew the rectum up behind on either side to the sacro-tuberous ligaments; in front the sutures anchoring the gut will catch the edge of both levators, drawing them together and shutting off the gap that otherwise would leave these muscles parted and unbraced—a crucial step, for here the forward knuckle of the rectum has pressed upon and forced the pelvic floor. J-shaped needles facilitate the insertion of sutures.

Intussusceptions

Invaginations of the colon into the rectum require laparotomy through which the surgeon can obliterate the rectovesical pouch by means of suture and fasten up the sigmoid with a peritoneal flap raised from the right iliac fossa. In other reaches of the gut, invaginations, led by papillomas, will sometimes cause acute obstruction.

(6) Lesions due to aberrant worms

These reactions to the worms and eggs that manage to survive in vessels other than the portal group, appear as nodules or masses in the skin, especially on the buttocks; in the conjunctiva; in the spermatic cord and the epididymis; and in the female genitals. If troublesome or ulcerous (and also to exclude malignancy and to reassure the patient), these lesions can be dealt with by the knife or diathermy, accompanied as usual by thorough medication.

REFERENCES

Ali Pasha Ibrahim (1928). Personal communication.

Alves, W , and Blair, D M. (1946a) *Lancet*, 1, 9.

— — (1946b) *Ibid* , 2, 556.

Cawston, F. G (1943) *Clin Journ* , 72, 71

Cort, W. W. (1928) *J Amer. med Ass* , 90, 1027

Dunlop, E. E. (1946). *Brit med J* , 1, 124

[illegible]

Mayer, M , and Pifano, C (1942) *Rev. Sanid. Assist social* , 7, 397.

Rankin, F. W (1926) *Surgery of the Colon.* New York; Appleton

Smyly, H J (1930) *Trans. R. soc Trop med* , 24, 39.

Stiven, H. E. (1929). *Brit J. Surg* , 17, 230

[References to other titles are given under Schistosomiasis in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1936), Vol. 2, p. 323]

of the past 16 years since Mixter and Barr called attention to the intervertebral disc lesion as a cause of sciatica has shown beyond doubt that the practitioner confronted with a case of sciatica would do well to think first of this among the possible causes.

Rarer causes

There are, of course, other causes of sciatic pain: any lesion which compresses the appropriate nerve roots or the sciatic nerve trunk may cause sciatic pain. Among such lesions, neoplasms of the cauda equina, tuberculosis of the lower lumbar vertebrae or sacro-iliac joints, and neoplastic deposits in the pelvis all have to be remembered. In actual practice these are all comparatively rare, and if the possibility of such lesions is borne in mind it should be fairly easy to differentiate them from the commoner disc lesion. One other fact which has emerged from the discovery of a proved pathological basis for sciatica is that sciatic neuritis (inflammation of the sciatic trunk or of its roots) is very rare, if indeed it occurs at all in cases of ordinary sciatica. This section thus will deal chiefly with the diagnosis and management of lower lumbar disc protrusions; lower lumbar because in practically all cases the lesion occurs in the fourth or fifth lumbar disc.

Sites of prolapse

Protrusion of an intervertebral disc may occur at any level of the vertebral column but there is a predilection for certain sites: in the cervical region the discs between the fifth and sixth, and sixth and seventh vertebrae are usually the ones affected, causing a kind of brachial neuralgia and pain in the neck; this is analogous in many ways to sciatica, but differing in prognosis and management because the cervical disc is not subjected to the same weight-bearing strain as the lumbar disc. In the thoracic region the lesion is usually at about the middle, and it may cause intercostal neuralgia and compression of the spinal cord with paraplegia (as may cervical lesions). In the upper lumbar region, disc lesions are rare, but when they occur they usually cause anterior crural neuralgia, and not sciatica

Gross anatomy

The gross anatomy of the intervertebral disc is well known: it is a pad of fibrocartilage with a rim of circumferentially-arranged fibres (the annulus fibrosus) enclosing a central core of softer material (the nucleus pulposus) which exists in a state of considerable pressure. The whole structure is well adapted for the dual function of binding two vertebrae together and acting as a shock absorber. The annulus fibrosus is weakest posteriorly, that is, where it abuts on the vertebral canal, and as a result of degeneration or traumatic or infective changes it may rupture (Fig. 276). It may rupture completely, in which case the pressure of the nucleus pulposus will force some of that structure out through the *rupture* to produce a small lump in the

Rupture of the annulus

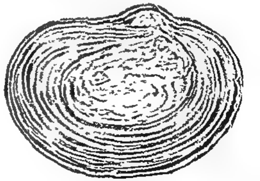

FIG. 276—Coronal section of fifth lumbar disc showing rupture of annulus fibrosus and protrusion of nucleus pulposus (*see* Fig. 277).

SCIATICA

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1. DEFINITION

301.] Sciatica is an affection characterized by neuralgic pain in some pa of the distribution of the sciatic nerve, for example, in the buttock, in th posterior aspect of the thigh and calf, and in the antero-lateral aspect of th leg and foot In the majority of cases it is preceded or accompanied by pair in the lower lumbar region which the patient usually describes as lumbago Both the back pain and the sciatica may occur in repeated attacks, with more or less complete freedom from symptoms in the intervals.

2. AETIOLOGY

In the majority of cases sciatica is due to compression of one or more of the lower lumbar and sacral nerve roots by posterior protrusion of an inter- vertebral disc. Not everyone will agree with this statement, but the experience

ervertebral c protrusion

form the patient experiences a sudden severe pain in the lumbar region, usually when he is doing something involving a mild strain with the trunk flexed, for example, lifting a weight while in the bending position. This pain probably bespeaks the initial rupture of the annulus fibrosus. It may be so severe as to make the patient faint; or of less severity, making it "difficult to straighten up"; or only severe enough to call attention to itself. It is usually worst at the onset, tending to wear off in a week or ten days. Thereafter the pain often is described as "moving from the back to the leg"—into the buttock, back of thigh and calf, or outer side of ankle and foot. As the sciatic pain develops, the back pain may clear up entirely or it may persist as a dull ache largely swamped by the more severe sciatic pain

Paraesthesiae

Along with the pain, the patient may experience paraesthesiae in the sciatic distribution: numbness, tingling or pins and needles, commonly in the calf and outer aspect of the ankle and foot. In few cases does the patient complain of muscular weakness: he is too much concerned with the pain to have tried the strength of his muscles.

These sensory experiences—and the findings on examination—indicate compression of the fifth lumbar and upper sacral nerve roots and they indicate that the protrusion is now lying in relation to these roots. Both the back pain and the sciatica are commonly aggravated by sudden movements such as jolting, coughing and sneezing, and by straining as in defaecation. Many patients find that standing and walking aggravate the pain, whereas others find that sitting is more uncomfortable than being up and about. Most can obtain a measure of relief by resting in the recumbent position, at least relief from back pain, although the sciatica may continue to demand analgesics for relief by day and for sleep at night.

Relief from pain

There are many variations of this state. The back pain may begin gradually, so gradually that the patient cannot assign a date to it. It may persist at nuisance level without ever being disabling, and in such cases it is generally the advent of sciatica which leads the patient to seek advice In some cases, the back pain and sciatica begin almost simultaneously, in others there may be an interval of weeks, months, or even years between the back pain and the sciatica. A few patients deny any back pain at all: in this connexion, it is often necessary to inquire about back pain as the patient may be so distressed by sciatica that he dismisses as irrelevant a previous attack of lumbago It is also worth inquiring about previous attacks of sciatica, because in many cases there will be a history of a similar attack some months or years before the present one

Degree of sciatic pain

The sciatic pain, too, may be of any degree of severity, from causing only slight inconvenience to, at the other extreme, severe and intractable pain which demands strong analgesics for even tolerable comfort. In either case it is remarkable how much demoralization can occur: quite phlegmatic individuals may be worn down by slight pain persisting for long enough, and for one who has not suffered from sciatica it may be easy to underrate the pain and to mistake the patient's attitude to it for a neurosis.

(1) Posture and mobility

It is possible in most cases to examine the patient standing and lying in bed. Attention is first paid to the lumbar spine. In some cases there may be no

vertebral canal. This protrusion commonly lies to one side of the middle line and is immediately anterior to the nerve root as it passes from the theca to the intervertebral foramen (Fig. 277). The nerve root may thus be squeezed between the disc lesion in front and the ligamentum flavum behind. In some cases the rupture of the annulus is not complete, only a part of its thickness being torn through, but this may cause sufficient weakness to allow the

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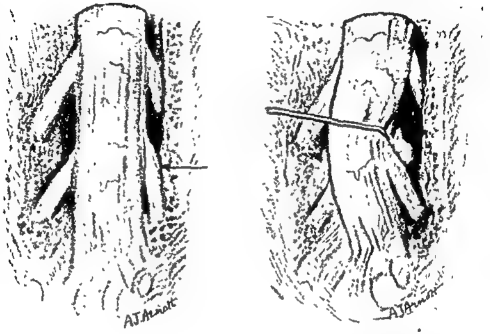

(a) (b)

FIG 277.—(a) Appearance of first sacral root displaced backward by disc protrusion seen in Fig 276, and (b) root and theca retracted to show disc protrusion

nucleus pulposus to create a bulge, if not a large swelling, which acts in a similar way to an actual nuclear protrusion. Either type of lesion may be small enough and situated far enough laterally to compress only one nerve root after it has left the theca, lesions of the fourth disc compressing the fifth lumbar root, and those of the lumbo-sacral disc compressing the first sacral root. In many cases, however, it is large enough to compress not only the one root in its extrathecal course but two or more of the lower roots within the theca as these roots run in a nearly vertical direction and are very close to one another. Thus a disc lesion may cause unilateral paralysis of that part of the cauda equina below the level of the lesion. A larger protrusion or one more centrally situated may compress the whole cauda equina and produce a bilateral paralysis. We have observed another type of lesion causing bilateral cauda equina paralysis and this is a small middle-line protrusion of the disc, insufficient in size to compress the cauda equina but associated with a dense band of adhesions within the theca which presumably strangles the nerve roots below it.

3. CLINICAL PICTURE

The clinical picture thus depends on the site and size of the lesion, but is in most cases that of a partial cauda equina lesion. In its simplest and commonest

Fig. 278.—Rigid lumbar kypho-scoliosis in a patient with a lesion of the fourth lumbar disc.

abnormality of posture, but in others the normal lumbar lordosis is lessened or obliterated to render the back "flat", or there may even be a slight kyphos in the lumbar region. There may be no deviation from the vertical or there may be a scoliosis with tilting of the pelvis so that one hip is more prominent than the other. The patient may find that he is more comfortable in the standing position if he bends his trunk forward and to one side, and some have grotesque attitudes which they cannot voluntarily correct (Fig. 278).

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In most cases movement of the lumbar spine is limited in all axes, especially in bending forward. If asked to bend to touch his toes, the patient may barely be able to get down to his knees, and in so doing one of several things may become apparent: if there is a normal lumbar curve in standing, this is maintained in flexion instead of being obliterated as normally happens (Fig. 279); a scoliosis may develop in flexion, or if already present may become more marked. These are probably the result of muscle spasm directed to immobilizing the affected disc and nerve root. Movement is painful in most cases, causing both pain in the back and sciatic pain, but in a few cases the patient will say that movement is limited more by rigidity or stiffness than by actual pain.

Fig. 279.—Persisting lordosis in flexion of trunk in a case of lumbo-sacral disc protrusion

(2) Naffziger's test

ression
ılar

While the patient is standing it is worth trying the effect of compression of the jugular veins in the neck. The examiner stands behind the patient and grasps the root of the neck

unilateral sciatica, which may not be very severe. The patient may give a sneeze, and experience an agonizing pain in the back and down both legs, which quickly passes off, and then he finds that his legs are numb and weak and that he is unable to empty his bladder. I have known the same thing to happen after manipulation of the back in the treatment of sciatica. It is as though there is a large loose fragment delicately poised which needs only the shift produced by a violent muscular effort, as in sneezing or by a forceful manipulation of the lumbar spine, to extrude it into the vertebral canal and compress the roots of the cauda equina. There may be almost complete muscular paralysis below the knees and in the buttocks and posterior femoral groups of muscles; the muscles are flaccid and become wasted, the ankle-jerks and plantar responses are absent. There is loss of all forms of sensation in the feet, the cutaneous sensory loss extending up the back of the calves and thighs to the buttocks and perineum (Fig. 280). The innervation of the bladder and bowel is so affected that there is complete retention of urine, and constipation with incontinence of faeces. The clinical picture is thus that of a complete lesion of the cauda equina such as may be produced acutely by a spinal injury or more slowly by a neoplasm. Since this type of lesion may result from therapeutic manipulation of the back, and as there is no way of predicting in which case it may occur, the author considers that spinal manipulation for sciatica is a potentially dangerous manoeuvre which should have no place in the treatment of intervertebral disc lesions.

Violent muscular effort

Retention of urine and constipation

(*c*) *Bilateral and alternating sciatica*

In the bilateral cauda equina paralysis described above, pain is not a prominent feature except at the onset. But bilateral sciatic pain and bilateral neurological abnormalities may occur with disc protrusions which are not large enough to crush the whole cauda equina. If a single lesion, it is usually situated near the middle line, but there may be a lesion of the fourth disc on one side and of the fifth disc on the opposite side, each producing its characteristic clinical picture at the same time; or the patient may have unilateral sciatica but recount a similar affection of the other leg some months or years before.

(*d*) *Absence of neurological abnormalities*

In a small proportion of cases there are no detectable neurological abnormalities The patient complains simply of back pain and sciatica, and on examination there may not be any abnormalities except limitation of movement of the lumbar spine and pain on the straight-leg-raising test. Operation in such cases may reveal a lesion fully as large as others associated with striking neurological abnormalities.

(6) Radiological examination

Skiagrams of the lumbar spine may not show any abnormality except a fixed postural deformity (such as scoliosis) if such exists. This is not surprising in view of the fact that the fibrocartilage is not opaque to x-rays. In many cases a lesion of the intervertebral disc can be inferred from narrowing of the space between the vertebrae, but this usually bespeaks an old-standing lesion and is often associated with arthritic lipping of the opposing vertebral bodies. X-ray examination of the vertebral column should always be done if for no

Muscle power

others. In assessing muscle power it must be remembered that the patient is often afraid to exert full voluntary power because of the fear of aggravating his pain. In such cases all movements of the painful limb are affected and not just those mediated by the sciatic nerve, and it is usually possible to obtain increased effort by encouragement and reassurance. It should be said, too, that in long-standing cases and especially in those severe enough to demand rest in bed, there is often wasting and flabbiness of all the muscles in the affected limb due to disuse.

Knee-jerk

The ankle-jerk is diminished or lost in the majority of cases of lumbo-sacral disc protrusion, but it is usually present in lesions between the fourth and fifth lumbar vertebrae unless it is a large lesion causing bilateral compression in which both ankle-jerks may be impaired. The knee-jerk is of no consequence in cases of sciatica: it may be a little more or less brisk than its fellow of the opposite side, but if enhanced it is usually because of the reinforcement which results from the patient screwing himself up when the painful limb is being tested. It may be less brisk because of the generalized muscular wasting and flaccidity which results from disuse of a painful limb. The plantar response is flexor.

Impairment of cutaneous sensibility

In addition to the pain and paraesthesiae there is usually some impairment of cutaneous sensibility in the sciatic distribution. This can be detected by testing with pin-prick and cotton-wool, and comparing the response to that on the normal limb. The defect is usually a relative one—not a complete anaesthesia or analgesia—and the common sites are the lateral border of the foot, ankle and lower third of the leg, and a strip on the lateral margin of the buttock extending for a variable distance down the postero-lateral aspect of the thigh, in the fifth lumbar and first sacral dermatomes (Fig. 280).

Weakness of gluteal muscles

When this part of the examination has been completed the patient is asked to turn over into the prone position. The gluteal muscles may be found to be flabby and weak, and the affected buttock sags so that the gluteal fold hangs at a lower level than its fellow. There may be some tenderness on pressure [illegible]

vertebrae.

(5) Variations in the neurological findings

(a) Paralytic lesions

Although slight degrees of muscular weakness and sensory loss are common, in a few cases they are profound. There may be such complete paralysis that the patient has a drop-foot with the slapping gait and instability of the ankle which occurs in that condition; and the sensory loss may be complete in the affected dermatomes. Such gross disturbance of innervation usually means severe root compression and as transmission of painful impulses may also be affected the patient may find that the pain ceases as the paralysis comes on.

(b) Cauda equina paralysis

The states referred to above result from lesions causing unilateral com- [illegible] bilateral paralysis of the cauda [illegible] massive protrusion, commonly [illegible] the lumbo-sacral level. In our experience this complication usually happens during a bout of ordinary

FIG. 281.—Myelogram of lumbo-sacral disc *protrusion* showing occlusion of root sheath and indentation of theca

FIG 282.—(*a*) Antero-posterior and (*b*) lateral myelograms in a case of protrusion of fourth lumbar disc causing cauda equina paralysis; opaque medium held up above the lesion.

(*a*)

(*b*)

the feasibility of dealing with it by a straightforward surgical procedure, it is now possible to afford immediate relief to most cases of sciatica and to lessen the likelihood of recurrences. As any surgical operation carries risks and as sciatica is generally not a matter of life or death, and as any attack may be the last one, there is general agreement that operation should not be resorted to until conservative measures have had an adequate trial and have proved unsuccessful. Of such measures rest is the first to be tried.

(1) Rest in bed

In some cases the rest should be complete, the patient lying flat on his back in bed, not getting up for toilet purposes or for his meals. Immobilization in a plaster bed is a most effective method of ensuring rest, and is particularly valuable in those cases in which even slight movement aggravates the pain. In either case, there may be need for strong analgesics for a few days until the acute pain begins to subside. Nursing such cases is difficult at home, and they are better treated in hospital. If the pain is severe enough to demand complete rest, it usually means a period of 4–5 weeks recumbency. At the end of this time the patient should be allowed up for a short period to see how he fares: if he continues to improve, he should be allowed to resume his normal activities gradually, but if the pain recurs, a further period of rest may be called for. *Plaster bed*

(2) Partial rest

In many cases the pain is not severe enough to warrant complete rest, and this probably represents the commonest type of the affection encountered in general practice. In such cases the patient should be advised to take things as easily as possible, to avoid lifting heavy weights or other exertions involving flexion of the trunk and to have mild analgesics necessary for reasonable comfort. Heat and light massage may give some relief and are worth a trial, but in some cases any kind of physiotherapy seems to aggravate the pain and should be discontinued forthwith. In these ambulant cases, injection of painful fibrositic nodules and epidural injections of saline or Novocain occasionally bring marked relief, but the pain is apt to recur when the effect of the injection has worn off. *Physiotherapy*

(3) Plaster jacket

In cases in which back pain figures largely, a plaster jacket often affords great relief and is worth a trial. If there is scoliosis the jacket should be applied with the patient suspended from the shoulders to allow the weight of the lower limbs to correct the deformity to some extent. If there is no spinal deformity, the jacket should be applied with the patient in his normal upright posture. It should extend from the mid-thoracic region down to grip the iliac crests, being cut out above the groins to avoid chafing, and in stout subjects it is sometimes necessary to cut a ventral window to allow for variations in abdominal tension. *Mode of application*

The effect of a plaster jacket is often dramatic: the patient may obtain almost immediate relief of back pain and sciatica, and be able to carry on with his normal occupation, even though it be manual labour. In many cases the relief is not so striking, and in a few the jacket seems to aggravate the pain or the patient is unable to tolerate the feeling of oppression or confinement, and in *Results*

have to be borne in mind. The sudden onset of back pain, the tendency for spontaneous recovery to occur, and the history of repeated attacks of much the same nature over a period of months or years are characteristic of the lesion described above and are unlike infections or neoplasms.

Tuberculosis

Neoplasm

In young subjects there are indeed few lesions which can make the differential diagnosis at all difficult. Radiography and lumbar puncture will do much to exclude tuberculosis and neoplasms, and careful myelography will tell with certainty whether or not the symptoms are due to a space-occupying lesion within the vertebral canal. In older subjects neoplasms in particular have to be considered, and a thorough search of the common sites for primary cancer, as well as careful x-ray examination of the lumbar spine and pelvis, are essential.

Osteoarthritis

Osteoarthritis of the lumbar spine is a common cause of back pain, and there may be sciatic radiation; but the back pain is usually a continuous dull ache and is rarely the acute and severe pain associated with intervertebral disc lesions. Similarly arthritis of the sacro-iliac joints may produce the syndrome, but in such cases there is usually clear evidence in skiagrams of the sacro-iliac joint. Neurological abnormalities are uncommon in these conditions, but otherwise the clinical picture may be similar. It should be mentioned that disc lesions may occur in elderly subjects who also have osteoarthritis, and in some the pain is severe enough to demand operative treatment. In such cases myelography is of great value in clarifying the diagnosis and in limiting the operation as much as possible.

Fibrositic lesions

A common difficulty in diagnosis arises from fibrositic lesions. Such lesions have received a great deal of attention and there is no doubt that they can cause a type of back pain and pain in the leg similar to that of a disc lesion. There are commonly painful nodules to be felt, the patient may admit to other fibrositic or rheumatic pains, and there are usually no objective neurological abnormalities, such as absence of the ankle-jerk, sensory loss in a root distribution or spinal deformities. The results of x-ray and cerebrospinal fluid examinations are usually normal. These cases are rarely as severe and protracted as those due to disc lesion, and can often be put right by Novocain injections into the painful nodules.

To recapitulate, the investigations in a case of sciatica include: (1) a thorough clinical history and examination, with especial reference to systemic evidence of infection or of a primary neoplasm in some other part of the body; (2) skiagrams of the lumbar spine and pelvis, especially for the exclusion of other causes of sciatica; (3) lumbar puncture to exclude the presence of a spinal tumour; and (4) in doubtful cases, myelography, which will tell if there is a lesion and, if so, demonstrate its site.

5. CONSERVATIVE TREATMENT

The most generally applicable and useful treatment for sciatica is rest. This statement reverts to the experience of the older clinicians who sooner or later arrived at the same conclusion after trying each new vaunted remedy for sciatica. New remedies were constantly being sought because although it was known that most attacks of sciatica would settle down in time, the pain might be very severe while it lasted, and there was always the risk of recurrence in the future. With the discovery of the intervertebral disc lesion and of

(2) Operative technique

The operation which is commonly employed now varies little from case to case and between different surgeons. It amounts to a limited lumbar hemi-laminectomy (Fig. 283) and removal of the extruded material compressing the nerve root. *Hemilaminectomy*

The skin of the lumbar region is thoroughly washed on the night before the operation, and if hairy shaved on the morning of operation. The author prefers general anaesthesia (nitrous oxide, oxygen and ether) to intraspinal and local anaesthesia, although some surgeons use these agents. *Operative preparations*

The patient is placed on the table in the prone position with the table broken sufficiently to flex the spine slightly: this is preferable to using the gall-bladder bridge or pillows under the abdomen because these cause engorgement of the venous plexus around the theca and may lead to troublesome bleeding. Some surgeons prefer the lateral position as blood tends to run out of, rather than collect in, the wound; and, indeed, if the prone position is used, an efficient suction apparatus is essential because the lesion is situated at the bottom of a cavity which may be 7–10 centimetres from the surface, and the surgeon must have a clear view of what he is doing. *Position*

When the patient is on the table the skin in the lumbar region is cleaned with Cetavlon and surgical spirit and a midline incision is made extending from the third lumbar spine down to the first piece of the sacrum. The sacrospinalis muscles are separated from the spinous processes and laminae of the fourth and fifth lumbar vertebrae. The author uses the endothermy cutting current for this purpose. Bleeding from the muscles is stopped by electrocoagulation and the muscles are held apart with self-retaining retractors. The bone is scraped clean with a chisel, and the ligamentum flavum between the fifth lumbar vertebra and the first piece of the sacrum is cleared. The spinous process of the fifth lumbar vertebra is removed with bone-cutting forceps and then the lower margin of the fifth lamina on the side of the lesion is removed *Incision*

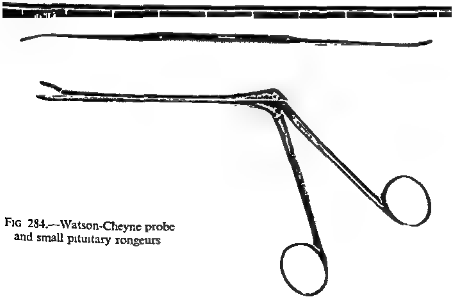


FIG 284.—Watson-Cheyne probe and small pituitary rongeurs

such cases the jacket should be removed. In cases in which it does afford more or less relief, it should be left on for 5 or 6 weeks. Thereafter it can be removed and the patient fitted with a lumbar corset, which he should wear for 4 or 5 months until he has regained his confidence and lost all his symptoms.

6. SURGICAL TREATMENT

(1) Indications

If the pain persists despite rest and the more or less complete immobilization of a plaster bed or jacket, the question of operation should be considered. The absolute indication for urgent operation is paralysis of the cauda equina: this is the one complication of sciatica which may endanger life, and the sooner it is dealt with the better. Most practitioners will also be familiar with the occasional case of severe sciatica which is not relieved by rest and simple analgesics, or requires frequent injections of morphine, and obviously drags the patient downhill every day the pain lasts. In such cases, too, there is no reason for withholding operation, and the result is usually very satisfactory for all concerned. In general, the other indications for operation are: (1) frequently recurring attacks of back pain and sciatica leading to time off work, interruption of domestic activities, and the insidious demoralization that goes with such repeated attacks; (2) chronic sciatica which has defied conservative treatment and persists as a cause of disability.

Choice of cases

It should be emphasized that the selection of cases for operation is not easy. It is common knowledge that most attacks of sciatica will settle down in time, that it is such an unpredictable affection that any attack may be the last one, and that, with the exception of cauda equina paralysis, it is not an affection which endangers life. The indications for operation set out in the preceding paragraph are derived from these considerations and in actual practice only a small proportion of cases of sciatica demand operative treatment. In properly selected cases there are few operations in surgery which are more satisfactory — and there can be little doubt that the operative treatment of the intervertebral disc is one of the outstanding surgical achievements of this century.

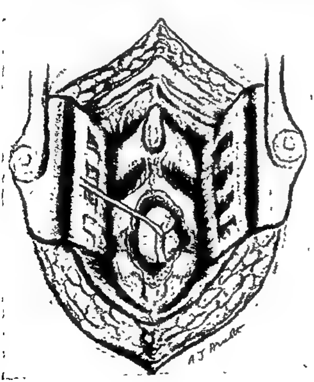


FIG. 283.—The usual exposure for lesions of the fourth and fifth lumbar discs; the lesion here is at the lumbosacral interval.

Because there may be lesions at both spaces, we commonly explore the fourth disc too. In some cases it may be possible to do this simply by excising the ligamentum flavum between the laminae of the fourth and fifth vertebrae, but sometimes this interval is so narrow that it is preferable to excise the fourth spine, and the lower margin of the fourth lamina first, as at the lumbo-sacral interval. If a lesion is found at this level it is dealt with in the same manner as described above. It should be mentioned, however, that if there is a large lesion at the fourth interspace it is often necessary to excise the rest of the fifth lamina to expose it properly and to deal with it adequately, as the lesion may curl downwards and damage may be done by trying to work through an inadequate aperture. In this connexion it should be said that it is possible to deal with disc lesions without removing any bone, that is by leaving the spinous processes and laminae and simply excising the ligamentum flavum (Fig. 285). This procedure has been abandoned, however, as in most cases it does not give adequate exposure, and it is not considered that the vertebral canal is appreciably weakened by excision of the spinous processes and fragments of laminae as set out above. *Exploration of fourth disc* *Treatment without bone removal*

(3) Wound closure

To minimize the risk of wound infection the whole wound is dusted with Sulphamezathine-penicillin powder, and as this may cause a certain amount of serous exudate a small rubber tube is led from the depths of the wound out through a stab wound to one side of the skin incision. The muscles are then drawn together with interrupted black silk stitches of which two layers are required and then the aponeurosis is approximated with interrupted sutures. The subcutaneous fat is closed with another layer, and the skin finally sutured with either interrupted black silk stitches or with a continuous suture. *Drainage*

(4) After-treatment

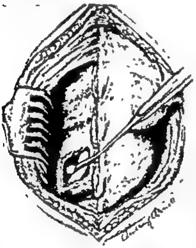
The drain is removed 24 hours after operation and the sutures are removed on the tenth day. There is no reason why post-operative drugs such as Omnopon should not be given for the first 48 hours, but generally analgesics are not required after that. Liquid paraffin should be given from the time of operation, and if no bowel action has occurred by the third day an enema should be given. The patient is nursed in the "three-quarter-recumbent position", taking his weight on one buttock, and is turned 4-hourly by day and when he wants to be turned at night—or when he wakes. If he is kept lying on one side the greater trochanters are apt to get tender and painful. After 4–5 days he can usually lie comfortably on his back, and from that time can begin to alter his own position in bed.

The author prefers to keep the patient in bed for 3–4 weeks after operation, but some surgeons advise earlier movement, say after 10–14 days. The time spent in bed can be usefully employed in massage and exercises for the lower limbs.

Once he starts getting up, the patient should do a bit more walking each day, and usually he is in good general condition by the end of another fortnight. Return to work depends on the nature of the occupation, but it is recommended that no heavy work or strenuous exertion be undertaken for three months after operation.

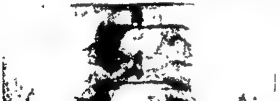
to expose an area of ligamentum flavum about 2 centimetres square. The ligamentum flavum is then excised, taking care not to cut the theca which lies immediately underneath, protected only by a layer of extrathecal fat of variable thickness.

The window thus made provides an opening through which the first sacral root can be seen. Normally this root is freely movable in the vertebral canal and there is sufficient room to allow a Watson-Cheyne probe (Fig. 284) to enter for a distance of about 1·5–2 centimetres. If a disc protrusion is present at this level, however, the root will be found to be fixed, and it will be difficult to get the probe into the vertebral canal. The extrathecal fat is then cleared from the root, and it is retracted medially. This exposes the disc protrusion, which is commonly a soft, white, pearly knob about the size of a pea or the tip of one's little finger. A longitudinal incision is made over the summit of the swelling and usually a fragment of white stringy material starts to protrude from the incision. This is grasped with forceps and teased out. It may prove to be one or two quite large shreds, almost the size of one's little finger, or there may be a number of smaller shreds. A small pair of



(a)

(b)



(c)

FIG. 285.—(a) Window exposure of lesion of fifth lumbar disc by simple excision of ligamentum flavum, (b) fragment of ligamentum flavum on the left, and two disc fragments at the right, and (c) post-operative skiagram showing bony integrity of lumbar spine.

pituitary rongeurs is the best instrument for dealing with these fragments (Fig. 284). When the presenting bits have been removed the swelling will be found to have disappeared and the root will be free. To prevent recurrences, however, it is essential to introduce the rongeurs into the interior of the disc and exenterate it.

7. RESULTS

With an affection which may be almost entirely subjective, assessment of results of operation is only less difficult than selection of cases for operation. In about 70 per cent of cases, the operation seems to provide almost complete and permanent relief of back pain and sciatica, and these patients may have nothing to show for their trouble but the scar in the back. In another 10 per cent there may be some residual back pain and occasional twinges of sciatica which are nothing like as severe as before operation. In another 10 per cent there may be sharp recurrences of back pain, rigidity, spinal deformity and sciatica which are usually due to extrusion of another fragment, and some of these require a second operation. Finally there are about 10 per cent of cases in which the operation seems to make little difference, although if properly done the patient should at least be no worse. It is not surprising that the results are unsatisfactory in some cases when we consider that a back which has sustained an intervertebral disc lesion can never again be normal; but as a result of operation or otherwise it may become practically normal, and the patient may find that his usual activities are in no way restricted.

[References to other titles are given under Sciatica in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 11, p. 26.]

(5) Complications

(a) *Infections*

Penicillin and Sulphamezathine

Infections of the wound have almost ceased to cause worry since the routine use of Sulphamezathine-penicillin powder was commenced. When infection does occur it is usually confined to the superficial layers, and subsides with local treatment.

(b) *Aggravation of neurological defect*

In large centrally placed lesions in which the theca has to be retracted strongly to one or both sides for exposure, the neurological abnormalities may be more marked after operation than before. In such cases it is sometimes preferable to open the theca and remove the swelling between the roots of the cauda equina. Even in straightforward cases, it is quite common for the ankle-jerk to be lost and the sensory loss over the foot to be more profound after operation because of damage to the root when it is being retracted.

(c) *Sphincter defects*

In some cases there is transient retention of urine for 3–4 days after operation. Intermittent catheterization is sufficient to deal with this, but if the paralysis is more profound, for example in cauda equina paralysis, a tidal drainage apparatus should be set up, and this should be maintained until voluntary control or effective automatic activity is established.

(d) *Back pain*

An occasional alarming but not serious complication is encountered after vigorous curettage of the interior of the disc. The patient usually has a normal convalescence until the second or third week, when he begins to complain of spasmodic and acute pain in the back. It may be worse than anything he had before operation. It is brought on by even the slightest movement and the patient is transfixed by fear of movement, and his immobility may lead to abdominal distension and the further distress which that causes. The pain is confined to the back, and if it does radiate it is to the groins, not into the sciatic distribution. In these cases skiagrams often show rarefactive changes about the end-plates of the vertebral bodies which lead the radiologist to suspect infection, but there is no febrile reaction or any other evidence of infection. Skiagrams taken weeks or months later show that a partial fusion has taken place between the vertebral bodies, and we regard this type of pain as a manifestation of the process of fusion. The treatment for this complication is complete immobilization in a plaster bed for 4–5 weeks. The patient is usually comfortable within a few hours of getting into the bed, and the late results in this group have been better than in any other. Thus although it may be alarming and distressing for the patient, he may be encouraged by the knowledge that the ultimate outlook is good.

Abdominal distension

Treatment

(6) Sciatica and pregnancy

Sciatica occurring during pregnancy should be treated as at any other time. If operation is called for on other grounds, pregnancy is not a contra-indication, and the patient should be able to have a normal labour subsequently.

inferior rectus muscle. All four rectus insertions are placed approximately over the ora serrata. The two oblique muscles are attached well behind the equator and do not normally affect surgical procedures. Tenon's capsule envelops the whole surface area of the sclera. Bulbar conjunctiva also covers its anterior one-third. The surgical anatomy of the corneo-scleral junction is dealt with in the article on Glaucoma (Vol. 4, p. 319). *Tenon's capsule*

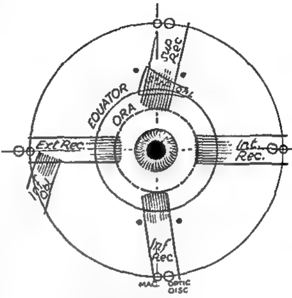


FIG. 286.—Muscle chart for detached retina, the four black spots show the positions of the vortex veins.

4. VARIATIONS IN STRUCTURE

The supporting powers of the sclera may be weakened, and its thickness very much diminished with or without the actual production of an ectasia, either from some inherent defect or from an increase in intra-ocular pressure. For example, in the late stages of unrelieved glaucoma, staphylomas may appear just behind the corneal limbus. Extreme thinning and stretching, chiefly posterior to the equator, is found in the high degrees of myopia. In the hereditary condition of "blue sclerotics", the scleral tissues are uniformly reduced and the choroidal pigment shows through the sclera.

5. SURGERY

(1) Rupture of the sclera

Rupture of the sclera is the commonest injury requiring surgical intervention. The site of rupture is usually the upper nasal quadrant, a few millimetres posterior to, and concentric with, the limbus.

Although the overlying conjunctiva is usually intact, herniation of uveal tissue may lead to serious complications and eventually to complete loss of visual function. Except in those rare cases in which the introduction of sepsis at operation would seem to constitute an even greater danger, or when the rupture is small and the anatomy little interfered with, it is advisable to attempt repair. *Indications and contra-indications*

Under local anaesthesia and akinesia of the orbicularis muscle, the rupture is exposed by turning back a flap of conjunctiva, and suturing this at 3-millimetre intervals, using No 000 silk on an eyeless needle. The wound margins are best held by fine scleral hooks. Before tying the sutures, any healthy prolapsed uveal tissue is replaced in the eye with a stroke of an iris repositor, but, if severely damaged, it is better excised with de Wecker's scissors. Before closure of the conjunctival flap with No. 000 silk sutures, the scleral surface *Technique*

SCLERA

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1. DEFINITION

302.] The sclera is a purely supporting structure in the eye. It is fibrous, relatively avascular, and consequently a tissue the diseases of which are comparatively rare and of simple pathology.

2. ANATOMY

The sclera is continuous anteriorly with the cornea and posteriorly, where it is perforated by the optic nerve, with the lamina cribrosa. It can be differentiated into three layers, which are from without inwards: the episclera, a loose fibrous structure, relatively vascular; the sclera proper, in which the fibrous tissue is arranged in densely packed bundles, almost avascular; and the inner elastic pigmented lamina fusca, in apposition with the choroid and ciliary body.

Three layers

At the equator the sclera is only 0·5 millimetre thick, but anterior to this the thickness increases to 1 millimetre.

The anterior ciliary vessels penetrate the sclera and form a fine network in the episcleral tissues just behind the corneal limbus.

3. SURGICAL ANATOMY

The surgical anatomy of the sclera is of great importance in ocular surgery, especially the relationships of the underlying uveal tract and overlying muscles (Fig. 286). When operating for detachment of the retina, for example, it is important to know that the average distance of the ora serrata from the corneal limbus is 7·5 millimetres, that the ciliary body lies between these limits, and that the four vortex veins penetrate the sclera some 7 millimetres behind the equator on either side of the superior rectus muscle and some 5 millimetres behind the equator in the case of the veins on either side of the

Ora serrata, ciliary body and vortex veins

Ocular muscles

(6) Differential diagnosis

Acute iritis and cyclitis

It should be remembered that, in acute iritis and cyclitis, engorgement of the anterior ciliary vessels produces a deep circum-corneal flushing (ciliary injection), a picture not to be construed as a true inflammation of the sclera or episclera. Conjunctival inflammation can be differentiated from episcleritis and scleritis by the absence of pain and tenderness on pressure, and by the pink-red, rather than violet-purple, coloration. *Conjunctivitis*

(7) Treatment

As has already been stated, local treatment of scleral inflammation is usually ineffective, apart from the relief obtained by hot steam bathings and, of course, by atropine when the uvea is secondarily involved. Salicylates are useful in the acute phase, and mercury and iodides in the more chronic phase. In the absence of any determinable cause, tuberculin and the general regimen prescribed for tuberculous patients may yield the best results.

7. NEOPLASMS

Primary tumours of the sclera are unknown, but this structure is, of course, often secondarily involved, most commonly in retinal glioma and choroidal sarcoma.

[References to other titles are given under Sclera in the Index Volume.]

should be dusted with penicillin powder. One per cent atropine sulphate drops are instilled and the eye is firmly padded and bandaged. The conjunctival sutures are removed after 4 days but the scleral sutures are left in place.

After-care

(2) Penetrating wounds of the sclera

Danger of sympathetic disease

Penetrating wounds of the sclera, especially those involving the ciliary body, may lead to an irido-cyclitis and "sympathetic" disease in the other eye. Such complications, however, are not common if one insists upon careful repair, abscission of all prolapsed tissue, covering the wound with a conjunctival flap and using an aseptic technique. All such cases must be carefully watched and, should the eye continue irritable and injected, excision must not be delayed too long.

6. INFLAMMATIONS

(1) Classification

Inflammations of the sclera are not common. Clinically, they are classified according to their depth (episcleritis and scleritis), according to their site (posterior, anterior or sclero-keratitis), and according to their extent (nodular and diffuse).

(2) Aetiology

Allergic response

Although the aetiology of these inflammations often remains obscure, it is nevertheless important that an attempt be made to determine the cause, since the response to local treatment is poor. Usually the condition appears to result from an allergic response to some infection, the most common of which is tuberculosis, especially in the sclero-keratitic variety. Focal sepsis (from teeth, tonsils and pelvic organs), rheumatism and gout are all possible allergens. Syphilis as a cause appears to be rare.

(3) Nodular episcleritis

Nodular episcleritis is the commonest variety. It occurs chiefly in elderly and in female patients as a purplish nodule (histologically a dense lymphocytic infiltration), very sensitive to the touch, firmly adherent to the underlying sclera and running a course of several weeks before absorption. Although the disease usually affects both eyes in turn and recurrences are the rule over a period, maybe, of years, the eyes are not seriously damaged. Slate-coloured atrophic scars mark the affected areas.

(4) "Episcleritis periodica fugax"

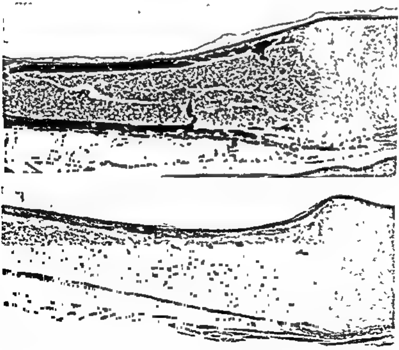
Another variety, also with a benign course, is "episcleritis periodica fugax", which involves diffuse areas of the anterior episclera and overlying conjunctiva. The congestion appears suddenly and disappears usually within 48 hours, leaving no trace. Pain is only slight.

(5) Scleritis

Fortunately, scleritis proper is rare, since it is one of the most serious of all eye diseases, responding hardly at all to treatment, and spreading frequently to the cornea, which becomes opaque (sclerosing keratitis), and to the underlying uveal tissues (sclero-uveitis).

body, but more eſpecially the legs, were ſubject to ulcers of the worſt kind, attended with rotten bones, and ſuch a luxuriancy of funguous fleſh, as yielded to no remedy. · But a moſt extraordinary circumſtance, and what would be ſcarcely credible upon any ſingle evidence, is, that the ſcars of wounds which had been for many years healed, were forced open again by this virulent diſtemper: Of this, there was a remarkable inſtance in one of the invalids on board the *Centurion*, who had been wounded above fifty years before at the battle of the *Boyne*; for though he was cured ſoon after, and had continued well for a great number of years paſt, yet on his being attacked by the ſcurvy, his wounds, in the progreſs of his diſeaſe, broke out afreſh, and appeared as if they had never been healed: Nay, what is ſtill more aſtoniſhing, the callous of a broken bone, which had been compleatly formed for a long time, was found to be hereby diſſolved, and the fracture ſeemed as if it had never been conſolidated. Indeed, the effects of this diſeaſe were in almoſt every inſtance wonderful; for many of our people, though con-

FIG 287.—Photostat reproduction from p 102 of *A Voyage Round the World* (Anson, 1748) (*By courtesy of Brit J. Surg*)



(*a*)

(*b*)

FIG 288—Costochondral junctions: (*a*) in a normal guinea-pig, (*b*) in a scorbutic guinea-pig (*By courtesy of Brit J Surg*)

SCURVY—MASKED AND MANIFEST

By ALAN H. HUNT, D.M., M.Ch., F.R.C.S.
Assistant Surgeon, St. Bartholomew's Hospital, London; Assistant Surgeon, Royal Cancer Hospital, London

1. DEFINITION

303.] Scurvy is a disease in which the intercellular supporting tissues of the body fail to be formed or to be maintained in a quantity or quality sufficient for the demands of the organism (Aschoff and Koch, 1919; Hojer, 1924; Wolbach and Howe, 1926). The substances known to be thus affected are collagen and reticulum, bone and cartilage and the enamel and dentine of teeth.

2. AETIOLOGY

Scurvy is due to a deficiency of vitamin C (ascorbic acid). This vitamin, it is supposed, acts as an oxidation-reduction enzyme, enabling the mesodermal cells of the body to deposit their respective matrices. (Anthropoids and guinea-pigs alone show this defect.) Misguided dietary restrictions, ignorance, apathy and poverty are the causes of scurvy, whether it be masked or manifest.

3 PATHOLOGY

(1) Manifest scurvy

In manifest scurvy, the vitamin either is absent or is present in such small quantities that the requirements of an otherwise normal and healthy individual are not supplied.

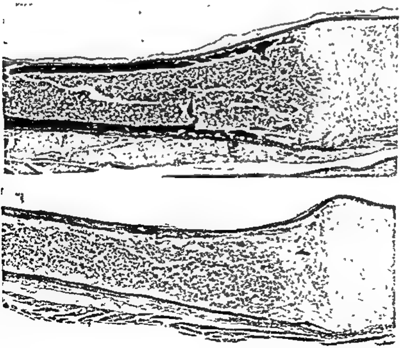
Atrophy of mesodermal interstitial substances

In adults, well-established mesodermal tissues, especially collagen, appear atrophied, the pathological picture is indefinite, however, and is apt to be confused by the effects of other deficiencies which are present in all but the most carefully controlled cases, such as that of Crandon's self-inflicted scurvy (Lund and Crandon, 1941) Crandon conclusively confirmed observations made two hundred and more years ago (Fig. 287), that wounds and, sometimes, healed fractures break down in scorbutic patients In the absence ... adult scurvy is the ...ticulum

Haemorrhages

> body, but more eſpecially the legs, were ſubject to ulcers of the worſt kind, attended with rotten bones, and ſuch a luxuriancy of funguous fleſh, as yielded to no remedy. But a moſt extraordinary circumſtance, and what would be ſcarcely credible upon any ſingle evidence, is, that the ſcars of wounds which had been for many years healed, were forced open again by this virulent diſtemper: Of this, there was a remarkable inſtance in one of the invalids on board the *Centurion*, who had been wounded above fifty years before at the battle of the *Boyne*; for though he was cured ſoon after, and had continued well for a great number of years paſt, yet on his being attacked by the ſcurvy, his wounds, in the progreſs of his diſeaſe, broke out afreſh, and appeared as if they had never been healed: Nay, what is ſtill more aſtoniſhing, the callous of a broken bone, which had been compleatly formed for a long time, was found to be hereby diſſolved, and the fracture ſeemed as if it had never been conſolidated. Indeed, the effects of this diſeaſe were in almoſt every inſtance wonderful; for many of our people, though con-

FIG 287—Photostat reproduction from p 102 of *A Voyage Round the World* (Anson, 1748) (*By courtesy of Brit J Surg*)



(a)

(b)

FIG 288—Costochondral junctions (*a*) in a normal guinea-pig, (*b*) in a scorbutic guinea-pig (*By courtesy of Brit J Surg*)

Interference with growth of bone

Epiphyseal fracture-separations

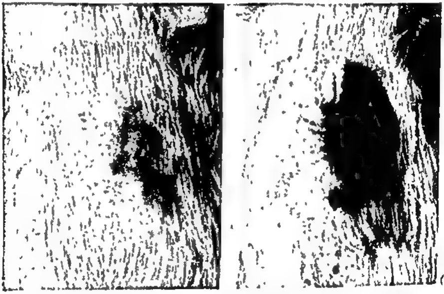
Subperiosteal haemorrhages

In children, on the other hand, osteoporosis, thinning of cortical bone and interference with bone growth produce changes as striking as those due to haemorrhages. Instead of the normal formation of bone there appears a dense and fragile zone of calcified cartilage adjacent to the epiphyseal cartilage. At this point fracture-separations of the epiphyses may occur. The red marrow shrinks and is replaced by a feltwork of proliferating mesodermal cells (*Gerüstmark*) (Fig. 288). The periosteum degenerates and haemorrhages frequently occur between it and the bone.

(2) Masked scurvy

In masked scurvy (synonyms: subscurvy, latent scurvy, asymptomatic scurvy) vitamin C is present in quantities sufficient to satisfy the requirements of a healthy individual but insufficient to meet any additional demands. In acute and chronic infections, injuries (including surgical operations) and in all malignant neoplastic diseases, the utilization of the vitamin is increased.

Experimental demonstration of the failure of the repair processes of soft-tissue incisions in subscorbutic guinea-pigs (killed 21 days after operation) is



(a) (b)

FIG. 289.—Healed abdominal incisions (*a*) in a normal guinea-pig; (*b*) in a subscorbutic guinea-pig (*By courtesy of Brit. J. Surg.*)

Wound healing delayed in experimental and human wounds

illustrated in Figs. 289–293. The level of vitamin C in the tissues at which such defects make themselves evident has not yet been determined. Macroscopically, the healing wounds of the subscurvy animals show a greater initial reaction to trauma than do the normal controls. Scabs come off later. The healed wounds are thicker, puckered, sunken, stretched and show a mauve discoloration. To the casual observer, however, the wounds appear to have healed well and the defects are evident only on comparison with identical control wounds. This has made the confirmation of the animal experimental findings a matter of considerable difficulty in human subjects. Microscopically, the whole architecture of wound healing is disturbed. The removal of damaged tissue and foreign material such as catgut is delayed (Fig. 293). The proliferation of fibroblasts is prolonged and the cells remain immature

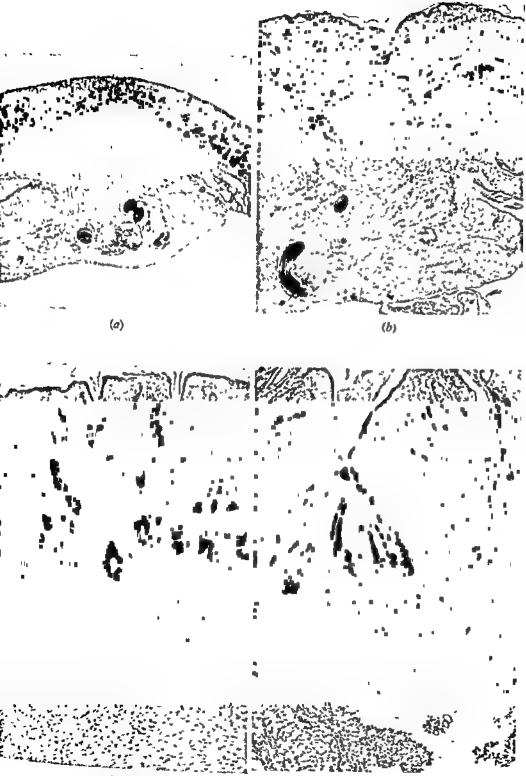
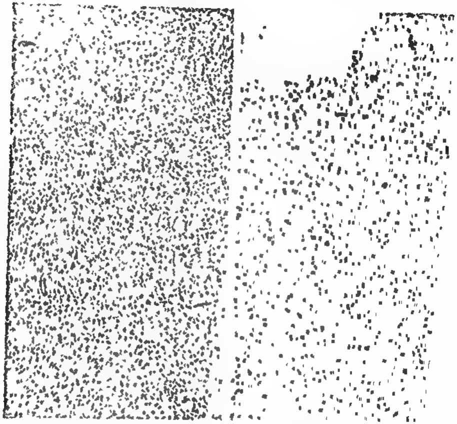


FIG 290 —Sections of healed abdominal incisions (a) and (c) in normal guinea-pigs; (b) and (d) in subscorbutic guinea-pigs (*By courtesy of Brit J. Surg*)

(Fig. 292). They deposit precollagen instead of collagen; and form an exces of weak, highly cellul ... split and broke by extravasations of ... although epithelial cell migration and proliferation are ... changes were found to occ ... person 6 months after begi ning a scorbutogenic diet and ... onset of scurvy (Lund a



(a) (b)

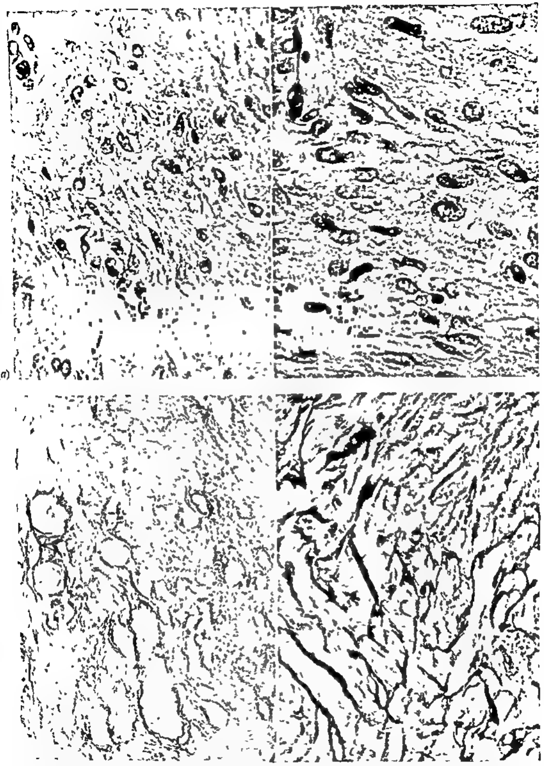
FIG 291.—Microphotographs showing low-power views of scar tissue: (a a normal guinea-pig, (b) in a subscorbutic guinea-pig (By courtesy *Brit. J. Surg.*)

Crandon, 1941) Hunt (1941) demonstrated a similar appearanc healing wounds of patients with deficiency of vitamin C (Fig 294).

The resultant healing in masked scurvy is thus a confused parod normal process. The response of such "scars" to any untoward stra evident. The wound, while showing excessive and ill-directed activi ... superabundant cellular elements, will break down from l ... this inability to withstand strain ...

by Bartlett, Jones and ... reached by the latter workers and by Wolff ... was observed that the wounds of human subjects in whom there prolonged vitamin C depletion exhibit a diminution of tensile s about 50 per cent during the second week after operation. Th

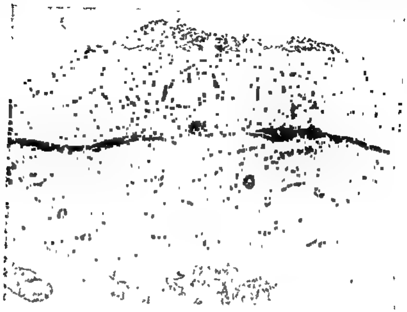
Tensile strength of healing wounds reduced in subscurvy



(a) (b) (c) (d)

Fig. 292.—Microphotographs showing high-power views of scar tissue, (a) and (c) in normal guinea-pigs, (b) and (d) in subscorbutic guinea-pigs. The sections (a) and (b) are stained with haematoxylin and van Gieson's stain, (b) shows the immature fibrous-tissue cells. The sections (c) and (d) are stained by silver impregnation, (d) shows the immature precollagenous intercellular substance. (By courtesy of *Brit. J. Surg.*)

acid content of the white-cell platelet layer of the blood must, however, be reduced to a level considerably below the normal level of 25–38 milligrams per 100 grammes for this effect to be observed. Saturation of the patient with vitamin C is thus not essential, although it is probably desirable.



(*a*)

(*b*)

FIG 293.—Healed gastrotomy wounds: (*a*) in a normal guinea-pig; (*b*) in a subscorbutic guinea-pig (*By courtesy of Brit. J. Surg.*)

4. CLINICAL PICTURE

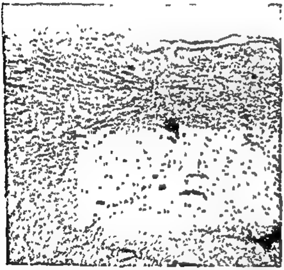
Delayed onset

Scurvy is a disease of insidious onset. It takes 3–6 months to develop (5 months in Crandon's controlled self-inflicted scurvy), the length of time depending upon the state of saturation with vitamin C before the beginning

of the causative alteration in diet. In its manifest form, scurvy is now a rare disease. In adults it is characterized by the following symptoms and signs, which are, however, often obscured by the effects of associated deficiencies. There is weakness, lassitude, loss of weight, spongy gums, anaemia and various haemorrhagic phenomena such as petechial haemorrhages into the skin around hyperkeratotic papules containing ingrowing hairs, massive haemorrhages into the muscles with pain on movement, haematuria and so on. There is said to be a reduction in the resistance to infections and in the detoxicating powers of the liver cells.

Debility, hyperkeratosis and haemorrhages in adults

(a)



(b)

FIG. 294.—Sections of abdominal skin incisions obtained at necropsy on human subjects dying (a) 12 days after operation, and (b) 13 days after operation (a) The tissues are saturated with vitamin C (b) A gross deficiency of vitamin C is shown (compare with Fig 290) Both sections were stained by silver impregnation (*By courtesy of Brit J Surg*)

In infants (Barlow's disease) the skin changes are seldom evident. Beading of the ribs, juxta-epiphyseal fracture-separations, subperiosteal and muscular haemorrhages, and pseudo-paralyses due to the pain of movement give a more striking and typical clinical picture.

Beaded ribs, epiphyseal fractures, haemorrhages and pseudo-paralyses in infants

In the masked subscorbutic condition, the patient shows no untoward symptoms or signs. The extent to which this partial deficiency of vitamin C accounts for post-operative abdominal disruption, leaking anastomotic suture lines and delayed union of fractures is uncertain. Protein deficiency is also known to be of importance (Clark, 1919), besides other less well-recognized biochemical factors There is little doubt that, in healing, these biological factors play a part subsidiary to mechanical considerations such as the correct technical closure of wounds and the approximation and immobilization of

fractures. Abundance of vitamin C does not excuse bad surgery. However, evidence has been adduced to show that vitamin C is grossly deficient in a considerable proportion of patients who have died as a result of deficient wound healing (Hunt, 1941).

5. SPECIAL AIDS TO DIAGNOSIS

Reference should be made to fuller studies of the subject (Bicknell and Prescott, 1946) for details of relevant tests. The most accurate method of determining the vitamin C content of the tissues is a chemical evaluation of the ascorbic acid content of the white blood corpuscles (the white-cell platelet layer). The excretion and saturation tests, and estimation of the plasma ascorbic acid, are of value clinically. Skiagrams are of diagnostic value in infants.

6. PRE-OPERATIVE MANAGEMENT

Saturation with vitamin C, followed by maintenance dose of 100 milligrams daily

Pijoan and Lozner (1944) consider on good evidence that a healthy individual is capable of maintaining an effective content of vitamin C in his tissues by means of the ingestion of a diet which supplies 25 milligrams of ascorbic acid daily. In view of the ready availability of ascorbic acid, however, and of the uncertainty as to how its metabolism is affected in times of physical stress, saturation of patients with vitamin C before operation is recommended, to eliminate one cause of possible breakdown of the wound. Ascorbic acid, 1,000 milligrams, is given daily for 3 days, followed by a maintenance dose of 100 milligrams daily This treatment is advised (a) when clean and quick healing of wounds is important, (b) before all major operations; (c) when a hollow viscus is to be opened, (d) when post-operative complications are anticipated; (e) when there is a history of insufficient intake of vitamin C due to dietary restrictions or to vomiting, (f) in all cases of serious injury, including fractures; (g) when fluids are to be administered parenterally over a long period, and (h) in all cases of chronic intestinal obstruction, chronic ulcerative colitis, carcinoma ventriculi and prolonged administration of alkalis, in which there is likely to have been destruction or failure of absorption of such vitamin C as has been ingested In this last group of cases the pre-operative dose should be increased and given with dilute hydrochloric acid, or given by injection. In patients with peptic ulcer the ascorbic acid should be given before meals and the alkali after meals

Dose increased when absorption of vitamin C is likely to be defective

7. POST-OPERATIVE MANAGEMENT

Rapid and early saturation

Vitamin C is concerned only with the formation of intercellular materials which do not begin to form before the fourth post-operative day. There is thus time to saturate the patient during this "lag period" of wound healing, provided that administration is begun promptly after operation. Patients receiving fluids by means of an intravenous drip should be given the vitamin in the infusion fluid, by the addition of 200 milligrams of Redoxon to each pint of glucose-saline solution for 3 days The maintenance dose should be 100 milligrams or more given daily until the patient is convalescent.

REFERENCES

Anson, G. (1748) *A Voyage Round the World.* Compiled by Richard Walter London; Knapton.

Aschoff, L., and Koch, W. (1919) *Scorbut. Eine pathologisch anatomische Studie.* Jena; Fischer

Bartlett, M. K., Jones, C. M., and Ryan, Anna E. (1942) *New Engl. J. Med.*, 226, 474.

Bicknell, F., and Prescott, F (1946) *The Vitamins in Medicine.* 2nd ed London, Heinemann.

Clark, A. H. (1919) *Bull Johns Hopk. Hosp*, 30, 117.

Hojer, J A (1924) *Acta paediat*, *Stockh.* (Suppl), 3, 8.

Hunt, A. H. (1941) *Brit J Surg*, 28, 436.

Lanman, T H, and Ingalls, T. H. (1937) *Ann Surg.*, 105, 616.

Lund, C. C., and Crandon, J H (1941) *J. Amer med. Ass*, 116, 663.

Pijoan, M, and Lozner, E L. (1944) *New Engl J Med*, 231, 14.

Wolbach, S B, and Howe, P R (1926). *Arch. Path*, 1, 1

Wolfer, J. A, Farmer, C J., Carroll, W. W., and Manshardt, D. O (1947) *Surg Gynec. Obstet.*, 84, 1.

[References to other titles are given under Scurvy—Masked and Manifest, in the Index Volume The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 11, p. 44]

SKIN–DISEASES OF, IN RELATION TO SURGERY

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1. DERMATITIS

(1) Definition

304.] Dermatitis is the term given to inflammation of the skin caused by (a) primary irritants which will produce inflammation of any skin, or (b) substances which are harmless to most persons but which produce changes in those who have developed an individual idiosyncrasy. This idiosyncrasy may be a natural inborn susceptibility or may be an acquired allergic state produced by previous contact with the agent. *Idiosyncrasy*

(2) Aetiology

The types of dermatitis which are of primary interest to the surgeon can be classified under the following headings.

(a) Traumatic dermatitis

This is caused by agents, such as acids and alkalis, heat and light, which produce an inflammatory change in the epidermis by physico-chemical action. *Skin damage by physical agents*

(b) Sensitization dermatitis

(i) *Chemical.*—For the production of sensitization dermatitis the chemical agent has to be in contact with the epithelial cells for some time. The epithelial cells during this period become sensitized and further contact with the agent at this stage causes dermatitis. *Allergic change in skin cells*

Although there is an individual variation in the ease with which skin cells can be sensitized, Bloch (1928) has shown that idiosyncrasy is only a matter of degree and that anyone can be sensitized to certain substances by increasing the duration of contact and the concentration of the agent. Nearly all chemical substances, when applied to epithelial surfaces, are capable of producing sensitization dermatitis. Thus, solutions instilled into the conjunctival sac, the external auditory meatus, vagina and rectum may all give rise to local dermatitis.

Another factor in the production of sensitization is the nutrition of the epithelial cells. If the blood supply is poor or if there is stasis, sensitization occurs more readily. *Nutrition of epithelial cells*

(ii) *Bacterial.*—Bacterial infection of the skin can predispose the epithelial cells to a chemical sensitization and also can sensitize the skin to bacterial

products alone. A superficial skin infection enclosed in plaster of Paris may produce an extensive "pyogenic dermatitis" beneath the plaster and, in addition, produce a generalized symmetrical dermatitis over the rest of the body.

This phenomenon of autosensitization, which was first recognized by Whitfield in 1930, takes some weeks to develop. Hecht, Sulzberger and Weil (1943) have suggested that the allergen responsible for the generalized dermatitis is a combination of staphylococcus toxin and broken-down skin proteins.

Although no age is exempt from sensitization dermatitis, it is very rare before puberty. Women at and just after the menopause and men in the decade 55–65 are more prone to dermatitis than are those at an earlier age.

The constitutional tendency to allergic eruptions is hereditary, and therefore a family history may give warning of undue susceptibility.

(3) Morbid anatomy

The pathological changes in dermatitis are the same irrespective of the aetiology. The first sign is erythema and this is followed by vesiculation. The vesicles rupture, leaving a moist exuding surface which later becomes crusted as the serum and dying epithelial cells dry.

Microscopically the sequence of events is: dilatation of the capillary loops of the papillae, intracellular and extracellular oedema of the prickle cells of the epidermis and, later, the formation of vesicles by rupture of the swollen cells and aggregation of the extracellular fluid. At the same time there is an infiltration of the surrounding region by leucocytes.

(4) Clinical picture

The clinical picture of acute dermatitis is characterized by redness and irritation of the skin, followed within a few hours by vesiculation. The vesicles burst, leaving a moist, weeping surface, though in mild cases this stage may not be reached, the vesicles drying without rupturing.

The mode of onset of the dermatitis varies with the agent which has caused it.

(a) Acute dermatitis due to natural idiosyncrasy of the individual

An acute dermatitis may follow the first application of an antiseptic used for pre-operative preparation of the skin. Within a few hours of the application the skin involved develops an angry red vesicular or bullous eruption. The eruption is most severe on those parts in greatest contact with the antiseptic, such as the back if excess fluid is allowed to flow on to the operation table, forming a pool in which the patient lies.

Antiseptic solutions in everyday use, such as iodine, biniodide of mercury, perchloride of mercury and Dettol, can cause this type of dermatitis in susceptible individuals.

(b) Sensitization dermatitis

(i) *Chemical.*—This commonly supervenes in the treatment of open wounds. After a local application has been used for some days, the skin around the wound becomes reddened and oedematous. Within a few hours vesicles develop in that area of skin in contact with the dressings.

Adhesive plaster of all types may give rise to local dermatitis (Fig. 295).

Acriflavine

Of the common applications, acriflavine is probably the most dangerous to the skin. Peterkin (1945) states that acriflavine can also light up sulphonamide dermatitis, and experimental work by Russell and Beck (1944) showed that mixtures of proflavine and sulphonamide were more lethal to tissues than was either substance singly.

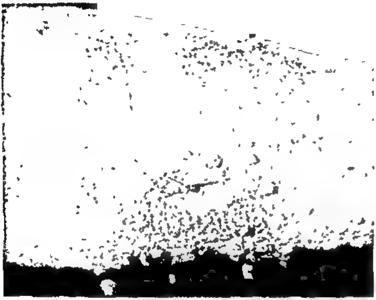


Fig. 295.—Sensitization dermatitis caused by zinc oxide strapping

Sulphonamide dermatitis

Sulphonamides, when used locally in wounds for periods of more than 4–5 days, may give rise to dermatitis (Fig 296). The individual sulphonamides vary in their power to produce dermatitis, sulphanilamide and sulphathiazole being more active in this respect than sulphadiazine or sulphamerazine. Exposure to sunlight is an additional factor in the production of sulphonamide sensitivity, and its incidence is higher in sunny climates

Once *sulphonamide sensitivity has developed, further local application to* a wound, or internal sulphonamide therapy, will produce a recurrence of dermatitis at the site of application and also a generalized dermatitis.

Sulphonamide light dermatitis

A troublesome variant of sulphonamide dermatitis is sulphonamide light dermatitis. Here the sulphonamide has the effect of sensitizing the skin to sunlight, and any exposure of the skin to sunlight thereafter will be followed by a weeping dermatitis on the exposed areas

Penicillin

Penicillin, when used locally, is remarkably safe. Michie and Bailie (1945) report one case of penicillin sensitivity in 30,000 wounded men of the British Liberation Army treated with penicillin. The majority of cases of proven penicillin sensitivity have been in doctors and chemists handling penicillin in concentrated solutions for long periods. Penicillin, however, as a cream, solution and powder can produce a definite dermatitis.

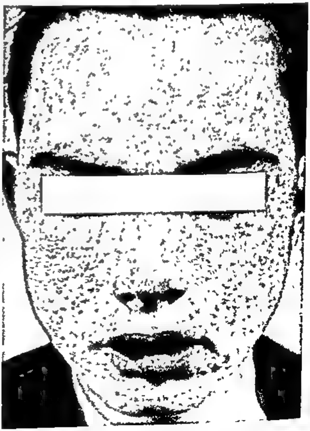
Dermatitis affecting the surgeon

Sensitization dermatitis may also present itself to the surgeon as a personal affliction. Dermatitis of the hands may result from contact with antiseptics, Novocain, penicillin and rubber gloves.

(ii) *Bacterial.*—Infectious eczematoid dermatitis frequently starts around some chronic discharging sinus or ulcer. A particularly common mode of onset is a spreading dermatitis beneath a plaster-of-Paris cast, which commences as a trivial infected skin abrasion. The eruption starts as small vesicles which rapidly become pustular. If this primary area of dermatitis persists for some weeks the whole skin becomes sensitized and a generalized symmetrical vesicular eruption may break out, affecting primarily the face, antecubital fossae, popliteal spaces and interdigital spaces of the fingers and, later, the skin over the whole body. This

So-called plaster dermatitis

(a)



(b)

Fig 296.—(a) Sulphonamide dermatitis caused by the application of a sulphonamide powder to an abrasion on the thumb; (b) eczematous eruption on the face of the same patient

autosensitization dermatitis tends to persist until the primary lesion has healed.

(5) Special aids to diagnosis

After assessment of the history and signs, the diagnosis of dermatitis should present little difficulty. It is, however, only after the closest inquiry into the various substances in contact with the skin that the causal agent can ever be deduced. Frequently an element of doubt remains and it is in these circumstances that the patch test is of value. This consists of the application to uninjured skin of a small piece of gauze soaked in the suspected substance in a concentration which will not cause irritation on normal skin. The piece of gauze is covered with oiled silk, Cellophane or old x-ray film and held *in situ* by adhesive plaster. *Patch test*

The patches are removed after 48 hours, when a positive result may be present, although a further examination of the area should be made after a week as sometimes the response is delayed. A positive response is shown by erythema and vesicles and, in markedly sensitive cases, a bullous eruption on the area of skin in contact with the patch. *Response to patch test*

A positive result is good confirmatory evidence that the patient's skin is sensitized to the substance tested. A negative result is of little value in excluding the substance, as sensitivity may be localized in the affected area of skin.

(6) Differential diagnosis

(*a*) *Erysipelas*

Erysipelas starting at the edge of a wound may be confused with dermatitis. The absence of pain, of pyrexia and of constitutional symptoms in dermatitis should help to distinguish the two conditions.

(*b*) *Impetigo and allied pyogenic infections*

These are characterized by pustules and yellow heaped-up crusts

(*c*) *Tinea cruris*

Tinea cruris, an acute irritating eruption with a vesicular edge, affecting only the axillae, groins and natal cleft, and due to the fungi *Epidermophyton inguinale* or to *Monilia albicans*, may simulate dermatitis. The demonstration of fungus mycelium or spores in scrapings of the skin makes the diagnosis clear.

(*d*) *Seborrhoeic dermatitis*

Seborrhoeic dermatitis may affect the same areas as tinea cruris, but the finding of severe dandruff in the scalp, and greasy scaly circinate patches over the sternum and between the scapulae, distinguish it.

(*e*) *Scabies*

The generalized autosensitization dermatitis may be simulated by scabies, and it is worthy of note that the symptoms of scabies may appear for the first time as long as 3 months after the initial infection, possibly many weeks after the patient has entered hospital. The diagnosis is proved by demonstrating the parasite.

(f) *Eczema*

The differential diagnosis between sensitization dermatitis and a constitutional eczema is very difficult. A history of previous attacks, a symmetrical eruption affecting the hands, feet and flexures, and the absence of an obvious external cause are findings suggestive of constitutional disease, but often the diagnosis remains in doubt.

(g) *Psoriasis*

In scars

Psoriasis commonly appears in wounds and scars, a phenomenon first described by Koebner The presence of typical lesions of psoriasis elsewhere, absence of irritation, and the dry red papule with silvery scales are diagnostic points.

(7) Prognosis

The majority of cases of acute contact dermatitis recover completely, provided that further contact with the causal agent is prevented. Sensitization remains for many years and therefore relapse will occur on any future contact with the agent. This is of great importance in dermatitis due to chemotherapeutic substances, in which skin sensitivity may interrupt internal treatment for a fatal disease.

Recurrence

It is also of significance when a surgeon develops dermatitis due to antiseptics or to rubber gloves

In a certain number of cases, the percentage of which it is impossible to assess, an underlying constitutional eczema is revealed, and in these the dermatitis will become chronic and may last throughout life. The size of this group can be diminished by early and expert treatment of the acute dermatitis.

(8) Treatment

There is no specific cure for dermatitis, and in many cases the treatment is prolonged and may hold up surgical procedures. Therefore any measures which can be taken to reduce the incidence are worth while.

The following points are worthy of note:

Preventive measures

Medicaments should not be applied to the skin or wounds unless absolutely necessary. Saline solution, Tulle Gras and possibly penicillin cream are safe applications

Pre-operative preparation of the skin should be reduced to washing with soap and water, Cetavlon and spirit.

Pyogenic infection of the skin should not be enclosed in plaster of Paris.

Chemotherapy should be given parenterally or by mouth.

The curative treatment may be described under two main headings, local therapy and general therapy.

(a) *Local therapy*

No matter what the aetiology, in the acute stage cool, wet, astringent [illegible] of gauze [illegible] in [illegible] er the early stages allay irritation and diminish the exudate. [illegible] impermeable covering should not be used, as it prevents evaporation and the skin becomes macerated.

Of the innumerable lotions which can be used ½ per cent silver nitrate, Liquor Plumbi Subacetatis Dilutus (*B.P.*), Lotio Calaminae (*B.P.C.*) and

Kaolin	1 oz.
Zinc oxide	1 oz.
Glycerin	½ fl. oz.
Water to	12 fl. oz.

are all valuable remedies.

An increased anti-pruritic effect can be obtained by adding phenol or menthol 1 per cent or Liquor Picis Carbonis (*B.P.*) 2 per cent.

Cleansing of the affected skin should be carried out by gentle sponging with gauze soaked in olive oil, arachis oil or liquid paraffin. Soap should be avoided. *Skin cleansing*

When the acute exudative stage has subsided, Lassar's paste is of value. To this may be added crude coal tar 3–6 per cent if improvement is only slow with the Lassar's paste alone.

In the subacute and chronic stages fractional doses of superficial x-ray therapy are of the utmost value, but consultation between the dermatologist and the radiotherapist as to correct dosage is essential. Skin atrophy will follow overdosage and must be avoided at all costs. A total dose of 1,000 r on one area should not be exceeded. *X-ray therapy*

(*b*) *General therapy*

If the dermatitis is at all extensive or involves the lower limbs and flexures, the patient should be treated at rest in bed This diminishes friction from clothing, lessens congestion in the legs and allows easy access for the application of dressings. Sedation is important, though other internal medication is of little value. Phenobarbitone, ½ grain three times daily, diminishes irritation and prevents the patient damaging himself by scratching. *The importance of rest*

The anti-histamine drugs are of value in the acute spreading generalized dermatitis if given in the early stages. Benadryl, 50 milligrams three times daily, will give considerable relief in the majority of cases. Parenteral penicillin may be used to control secondary infection, and is of value in the primarily infective dermatitis. Once the sepsis has been controlled, the penicillin should be discontinued and the dermatitis treated by local measures. *Anti-histamine drugs* *The control of secondary infection*

(*c*) *Internal therapy*

Sulphonamides can also be used to control secondary infection provided that no local sulphonamide has been used.

Desensitization to the causal agent has been attempted in a few cases of sulphonamide dermatitis and penicillin dermatitis, but the results are equivocal.

2. PRURITUS *ANI ET VULVAE*

(1) Definition

The term pruritus is given to the subjective sensation of itching when it is brought about by non-physiological stimuli Pruritus may be generalized or localized. By far the commonest sites of localized irritation are the perianal region and vulva.

(2) Aetiology

Pruritus *ani et vulvae* may be provoked by local causes or indirectly by constitutional or psychological disorder The aetiology may be further

Habit of scratching

Idiopathic pruritus

complicated by local skin changes produced by the prolonged hal scratching which may perpetuate the condition. Even after exhaustive ph and psychological investigations, a large "idiopathic" group remai which no cause can be found.

Causative factors

The prominent causes can be tabulated as follows:

(1) Local irritation from discharges from the anus or vagina, or irrit from chemical contraceptives.

Parasites

(2) Parasites. Threadworms; pediculi. Yeasts (*Monilia albicans*) and fungi. *Trichomonas vaginalis*.

(3) Local inflammatory conditions. Fissure; fistula; haemorrhoids. Co lomata lata and acuminata. Leucoplakia. Kraurosis vulvae.

(4) Local skin disease. Psoriasis; lichen planus; seborrhoeic derma eczema.

(5) Constitutional conditions. Diabetes mellitus; jaundice; pregnancy menopause; blood diseases.

Anxiety and frustration

(6) Psychological causes. Klaber (1947) emphasizes that mental irrit is a constant concomitant of skin irritation. Each undoubtedly aggra the other, and frequently an underlying anxiety or frustration will lea perpetuation of pruritus caused by some organic lesion. Removal of organic lesion will not in such cases cure the pruritus.

Anxiety, frustration and obsessional trends all may cause pruritus *a vulvae* in the absence of any organic lesion.

(3) Pathology

There are no specific changes of the skin in pruritus *ani et vulvae*. pathology is that of the underlying cause.

Lichenification

Whatever the cause, however, long-continued scratching produces lich fication. This is characterized by a thickened leathery change in the s with a mosaic-like surface composed of flat elevated planes and exaggera of the skin furrows.

(4) Clinical picture

Spasmodic irritation

The irritation of pruritus *ani et vulvae* is essentially spasmodic with remissi lasting hours or days. Irritation may be started by a stimulus such as defa tion or micturition but in severe cases it may arise spontaneously and awaken the patient from sleep. In many cases vulval irritation is worse before or after menstruation The irritation is so intense that the patient fi sleep impossible and life intolerable.

Absence of changes in the skin

In the large group of idiopathic cases no local change may be present in early stages or, at most, erythema and excoriation of the epidermis may seen—a result of scratching More chronic cases may show lichenification

Moniliasis, the common cause of pruritus in diabetes mellitus and pregnancy, may be recognized by the milky-white sodden epithelium, places showing a red glazed surface. Small flaccid vesicles are often present the periphery.

Local inflammatory conditions, leucoplakia and skin diseases are s evident on examination.

(5) Differential diagnosis

A careful history, which includes investigation of possible causes of mental stress and a complete physical examination are essential in the investigation of a case of pruritus *ani et vulvae*. Proctoscopy and vaginal examination should be performed if the diagnosis remains in doubt, and before classing a case as idiopathic further special diagnostic measures should be taken.

(6) Special diagnostic measures

Diagnosis of threadworm

Although not a common cause of pruritus ani in adults, threadworm (*Oxyuris vermicularis*) infestation does account for a certain number of cases. The diagnosis may be confirmed by finding adult parasites in the faeces or by demonstration of the ova in scrapings of the perianal skin.

Tests for fungus

Confirmation of the diagnosis of monilial infection can be obtained by the finding of mycelium or spores in microscopical examination or by culture of skin scrapings

Trichomonas vaginalis infection, a common cause of pruritus vulvae in pregnancy, may be confirmed by the demonstration of the motile organisms in a hanging-drop preparation of vaginal discharge.

(7) Prognosis

In those cases in which an organic cause can be found, the prognosis is good and complete cure can be anticipated. In the idiopathic and psychogenic group of patients the great majority are greatly improved by treatment, but the success depends to a large extent upon the confidence of the patient in his surgical adviser.

(8) Treatment

In all cases in which organic cause for the pruritus can be found, specific treatment to remedy the condition can be carried out.

In the remaining cases, which comprise the idiopathic, psychogenic and constitutional groups, treatment is directed to interrupt the vicious circle of irritation-scratching-lichenification-irritation.

Reassurance

Cancerophobia

Reassurance plays a great part in the successful management of these cases. The patient is usually anxious, sleepless and frequently a prey to fears of cancer or venereal disease. Explanation of the harmlessness of the disease, that worry is the essential cause, and that self-discipline is necessary to stop further scratching, is helpful. In all cases the following rules are of value.

Hygiene

After defaecation the anus should be cleansed with cotton-wool and warm water; soap should never be used. Whenever itching is severe anti-pruritic lotion should be used instead of scratching. Mild sedation both day and night with phenobarbitone is of great assistance in allaying anxiety and irritation.

Of the many anti-pruritic applications, the following is effective and unlikely to produce sensitization:

Phenol	60 gr.
Kaolin	1 oz.
Zinc oxide	1 oz.
Glycerin	½ fl oz.
Water to	12 fl. oz.

Anaesthetic ointments

Anaesthetic ointments should be avoided as their effect is very temporary and the active agents are prone to give rise to a sensitization dermatitis which perpetuates the pruritus.

Superficial fissures can be treated by painting twice daily with 1 per cent aqueous silver nitrate solution.

X-ray therapy

Superficial x-ray therapy is of great value in controlling the irritation in the idiopathic group and in those cases which have developed lichenification, but it should be combined with the local and general treatments described above. Control of irritation by x-ray therapy reinforces verbal reassurance and restores belief that the condition is curable. The danger of overdosage with x-rays should constantly be borne in mind. Failure to respond to one course of treatment should lead to a review of the diagnosis rather than to more x-ray therapy.

(9) Indications for surgical intervention

The great majority of cases of pruritus *ani et vulvae* respond to medical measures and the removal of the organic cause if such exists. Cases which do not respond are rarely benefited by surgical measures.

Claims have been made for the success of injections of local anaesthetics, but in many cases the relief is only temporary.

Surgical measures, such as the excision of the itching area with undercutting of the surrounding skin, are drastic and also frequently fail to relieve the pruritus.

In only one condition, the pre-cancerous leucoplakia vulvae, is excision of the affected area justifiable and of real benefit.

3. PYOGENIC GRANULOMA

(1) Definition

The name pyogenic granuloma is given to a small tumour due to a localized exuberant overgrowth of granulation tissue secondary to pyogenic infection.

(2) Aetiology

These small tumours arise on the site of a trivial injury, fissure or sinus. Infection with pyogenic cocci prevents healing and an overgrowth of young connective tissue and young blood-vessels occurs.

(3) Morbid anatomy

Histology

Histological examination shows that the tumour is composed of young connective tissue and numerous newly formed blood-vessels with an infiltration of leucocytes and plasma cells. The blood-vessels may predominate to such an extent that the appearance simulates that of angioma.

(4) Clinical picture

Sites of lesions

These small tumours appear most frequently on the scalp, face, hands and forearms (Fig. 297). Of a dark red-purple colour, they have been likened to raspberries. Sometimes pedunculated, they are always friable and bleed

Rate of growth

profusely when damaged. Their rate of growth varies greatly, but they may

reach a diameter of 1 centimetre in a few weeks and then remain unchanged for many months. If superficially removed they recur rapidly.

FIG 297.—Pyogenic granuloma on the back of the scalp which arose on the site of an abrasion from a comb.

(5) Differential diagnosis

Pyogenic granulomas have to be distinguished from the following conditions.

(a) *Cavernous angiomas*

Cavernous angiomas appear at birth or within a few weeks of birth, grow only slowly and are less prone to haemorrhage on slight trauma.

(b) *Squamous-cell epitheliomas*

These grow more slowly than pyogenic granulomas, are more indurated and usually have a central warty outgrowth. It is only when rapidly growing and ulcerated that difficulty may arise. A biopsy and histological examination will confirm the diagnosis if doubt exists.

(c) *Naevocarcinomas and melanomas*

These may also present as rapidly enlarging purplish tumours which bleed easily, but they are less friable than are pyogenic granulomas and nearly always arise from pre-existing pigmented naevi. Here again histological examination may be required if, on clinical examination, doubt exists.

(6) Surgical treatment

Pyogenic granulomas can be removed under local anaesthetic by (a) destruction by electrical cautery; (b) electro-desiccation; or (c) scraping and chemical cauterization with solid silver nitrate, copper sulphate or potassium permanganate. *Removal*

4. CHRONIC PARONYCHIA

(1) Aetiology

A chronic indolent infection of the nail-folds of the fingers may be caused by infection with the yeast-like fungus, *Candida albicans*. It occurs in those whose hands are constantly in water, such as housewives, barmaids, cooks and fruit canners and not infrequently in diabetics who have a monilial infection of the vulva from which the fingers become infected. The primary cause is the maceration of the nail-folds which separate from the nail-plate and allow the ingress of the organism. *Occupational hazard* *Relationship with diabetes*

(2) Clinical picture

In the acute stages it is difficult to distinguish monilial paronychia from staphylococcal infections. The chronic stage can be readily recognized, however, by the cushion-like, tender, red thickening of the nail-fold which is separated from the nail-plate.

Changes in the nail

From time to time exacerbation of pain and swelling occurs and then pus is discharged from the nail-groove. The nail-plate becomes eroded at the edges, thickened and deformed by transverse furrows. The infection tends to involve one finger after the other over a period of months or years, being spread by manicuring or by a continuance of the occupation which predisposes to the infection. Sometimes erosion of the skin of the webs between the fingers is present and this will assist in making the diagnosis.

(3) Special diagnostic measures

Culture

The infecting organism, *Candida albicans*, can be demonstrated by culture of pus from the nail-fold. Unlike other fungus infections, examination of scrapings of the skin around the nail is usually negative.

(4) Differential diagnosis

The clinical characteristics serve to distinguish the condition from pyogenic paronychia. Other fungus infections of the nails affect the nail-plate primarily and rarely involve the nail-fold.

(5) Treatment

The essential of treatment

An essential of treatment is to keep the affected finger dry. A spirit solution of one of the aniline dyes is the best local application. This should be painted over the whole nail twice daily and allowed to run down into the nail-fold. Gentian violet 1 per cent, brilliant green 1 per cent, and basic fuchsin in the form of Castellani's paint are all effective.

Fractional doses of superficial x-ray therapy to the nail-fold diminish the chronic thickening and accelerate recovery. The danger of x-ray overdosage should be borne in mind.

Duration of treatment

Treatment with the dyes should be continued for 3–4 weeks after all symptoms have subsided in order to prevent relapse. Another useful treatment to prevent relapse is the daily inunction of a water-miscible cream containing 10 per cent sodium propionate.

Surgical treatment is never necessary.

5. SENILE KERATOSIS

(1) Definition

[illegible] in [illegible] on any part of the body.

(2) Aetiology

Pre-cancerous change

Senile keratosis is a pre-cancerous hyperplasia, a response to chronic irritation. The lesions occur most commonly in those who have led outdoor lives

and whose skin has been excessively exposed to the elements. Similar keratoses occur at an earlier age in those who are exposed for years to tropical sunlight, tar and its derivatives, or the internal administration of arsenic.

Related to solar and arsenical keratoses

(3) Morbid anatomy

Histological examination shows thickening of the horny layer with alternating parakeratotic and hyperkeratotic areas. Irregular acanthotic thickening of the stratum mucosum is present and epidermal buds and whorls are seen. Freudenthal (1927) points out that the basal layer is often separated from the prickle cells by a gap There is often a lymphocytic infiltration.

(4) Clinical picture

The lesions occur most commonly on the face, around the forehead and temples. They arise as yellowish rough areas, at first barely raised but later developing an elevated warty appearance. The hard crusted surface becomes brown or black and is very adherent to the underlying skin. Its removal leaves a raw bleeding area. Surrounding the lesion there is frequently an erythematous ring. Senile keratoses may occur singly, though more frequently they are multiple. Spontaneous cure occurs occasionally and a smooth atrophic patch then marks the site of the healed keratosis. By far the commonest course, however, is for the keratosis to change to a squamous-cell carcinoma. All senile keratoses should be looked on as pre-malignant.

Spontaneous cure

Conversion to squamous-cell carcinoma

(5) Differential diagnosis

(a) *Seborrhoeic warts*

These also occur in the elderly, but are softer and more greasy than in keratosis and appear to be on, rather than in, the skin. Their greasy crusts are easily removed. They are multiple, and are found on the trunk and only very rarely on the face and hands.

(b) *Pigmented moles*

The majority of these are present at birth or appear in early life. The presence of pigment and their smooth surface continuous with the surrounding skin should serve to distinguish a mole from keratosis senilis.

(6) Treatment

Of the many methods of removal in current use, the following are effective:

(1) Chemical destruction. Trichloracetic acid should be applied to the keratosis on a glass rod, the surrounding skin being protected by Vaseline.
(2) Freezing for 30 seconds with a carbon dioxide snow pencil.
(3) Surgical excision.
(4) Electro-desiccation.
(5) Superficial x-ray therapy.
(6) Radium

Early lesions are best treated by trichloracetic acid or carbon dioxide snow pencil. Larger lesions require electro-desiccation or radiotherapy. A careful follow-up is necessary in order to treat any recurrence.

REFERENCES

Bloch, B. (1928) *Klin. Wschr.*, 7, 1065.

Freudenthal, W. (1927). *Recent Advances in Clinical Pathology.* London; Churchill.

Hecht, R., Sulzberger, M B., and Weil, H. (1943). *J. exp. med.*, 78, 59.

Klaber, R. (1947). *Brit J. Derm Syph.*, 59, 1.

Michie, W., and Bailie, H W. C. (1945). *Brit. med. J.*, 1, 112.

Peterkin, G. (1945). *Brit. med J.*, 2, 1.

Russell, Dorothy S., and Beck, Diana J. K. (1944). *Brit. med. J.*, 1. 112.

Whitfield, A. (1930). *8me Congrès international de Dermatologie et de Syphiligraphie, Copenhague*, p 142.

[References to other titles are given under Skin—Diseases of, in relation to Surgery in the Index Volume.]

SPEECH THERAPY

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1. CLEFT LIP AND PALATE: SUBMUCOUS CLEFT

305.] During the greater part of normal speech the nasopharynx is occluded by the action of the palato-pharyngeal sphincter and the breath is directed outward through the mouth With a cleft of the hard or soft palate excessive nasality takes the place of oral resonance and distorts the character of both vowels and consonants. Many consonants cannot be effected either because the breath stream, escaping through the nose, is too weak to produce a plosive, or a fricative, sound or because the necessary contact cannot be made between the tongue and the hard or soft palate. The resultant speech is distorted and may be unintelligible

Excessive nasality

Post-operative speech depends primarily on the extent to which surgical repair has achieved closure of the hard palate and has provided a competent velum capable both of occluding the nasopharynx and effecting the rapid movements required in normal speech. If the physiological mechanism is successfully restored before speech habits are fully established in the child, speech should develop normally, but the patient must be reviewed periodically by surgeon or speech therapist in case speech guidance becomes necessary.

Competent velum

For a child or adult, when operation is performed after speech is acquired, or if it is not possible to provide a competent velum, speech therapy becomes necessary and may result in greatly improved function The task is then either to correct pre-operative speech habits and to teach the patient how to make use of the new mechanism or to enable him by skilled adaptation to reduce the disability resulting from his residual organic defect. Treatment may be required continuously or intermittently over a long period. Although it is seldom practicable to begin the correction of defective sounds until a child is 5 years old much may be done before that age, by play therapy and advice to the mother, to promote the development of normal speech movements.

Post-operative therapy

The above treatment applies also to a submucous cleft and to cases in which an obturator is substituted for, or supplements, an anatomical repair.

Cleft lip seldom calls for post-operative treatment, but exercises are useful in promoting flexibility and the correct use of the lip movements in speech.

2. POST-ADENOIDECTOMY TREATMENT

Prolonged pressure of adenoid tissue upon the soft palate before adenoidectomy occasionally results in a post-operative inactivity of the velum. In such cases the patient continues to speak as though the nasopharynx were obstructed (and to breathe through the mouth) or alternatively the velum may remain in a lowered position and excessive nasality result. This dysfunction calls for exercises to restore activity in the velum and lip muscles and hygienic respiratory habits.

Enlarged tonsils and adenoids

Enlarged tonsils and adenoids are sometimes associated with disorders of articulation for which they may not be wholly responsible. Even when the condition is a contributory factor in the development of articulatory defects, it is unlikely that the speech will correct itself after surgical intervention alone. In such cases operation should be followed by speech therapy.

3. APHASIA

Speech therapy may be of great value in the rehabilitation of patients suffering from dysphasia or aphasia as a result of a cerebral lesion, including post-operative and traumatic cases.

Expectation of recovery

The indication for treatment depends upon the general prognosis, but when the expectation of recovery is good and a spontaneous return of speech is delayed or restricted, speech therapy should be attempted. It is better begun at an early date, once the patient is recovered sufficiently to co-operate in order both to provide reassurance and to prevent the development of mental apathy. Speech therapy may have to be continued over a period of years, response is sometimes long delayed and treatment should not readily be abandoned on this account.

The full neurological findings, including the visual fields, visuo-spatial construction and psychometric tests should be available. A careful analysis of the speech is made by means of observation and a selected test battery to ascertain the precise nature and degree of the language impairment before treatment is begun.

Dyslexia and dysgraphia

Dyslexia and dysgraphia, which are often associated with dysphasia and cause much distress to the patient also require skilled re-education to which they often respond well.

4. LARYNGECTOMY

After total laryngectomy has been performed, patients are left with the articulatory organs intact, but they are without the mechanism to supply the air and voice stream normally used in audible speech.

There are two methods of establishing audible speech: (1) by the use of an artificial larynx, and (2) training to use oesophageal voice.

(1) Use of artificial larynx

The artificial larynx is a small metal instrument, cylindrical in shape and containing a reed; two rubber tubes are attached to the instrument, one is

inserted into the tracheal cannula and the other placed between the lips. Air expired from the lungs passes into the cylinder, setting the reed in vibration and producing an action similar to that of the vocal cords. This vibrating column of air, or artificial voice, passes into the mouth, thus supplying the sound for articulation, and issues as audible speech. *Action similar to vocal cords*

Patients need some guidance in the use of this instrument but with practice they soon become proficient.

(2) Oesophageal voice

By the use of this method the patient can be taught to speak fluently and audibly without any artificial aid.

The oesophagus and stomach are used as substitutes for the larynx, trachea and lungs. Air is swallowed and held for a moment in the oesophagus and stomach whilst the sphincter at the top of the oesophagus is contracted. The swallowed air is then forcibly expelled thereby creating vibrations as it passes the sphincter. This is oesophageal voice; the procedure is similar to that of a prolonged belch. *Sphincter contraction*

The patient must learn to swallow and regurgitate air automatically before he uses it for speech. When this stage is reached, carefully graded exercises are given until the supply of "voice" can be controlled and fluent speech established.

The age, temperament and intelligence of the patient must be considered before embarking upon this treatment. Given a suitable and co-operative patient, very good results can be achieved. All patients need a great deal of encouragement and guidance. *Suitability of patient*

5 LARYNGOFISSURE

Laryngofissure, with removal of one or part of one cord, though it leaves the patient able to whisper, seriously affects phonation. The degree to which the voice may be restored depends on the amount of tissue excised and the extent of injury to the nerve supply.

Treatment consists in exercising the remaining vocal cord in order to increase its normal field of movement over the midline, and thus achieve a narrow, though crooked, glottis. When this is accomplished the patient should be given further voice training. *Treatment*

6. THYROIDECTOMY

Paralysis of the recurrent laryngeal nerve, unilateral or bilateral, may be a complication of thyroidectomy. In unilateral paralysis affecting the abductor muscles the voice remains practically normal, but should the adductor muscles be affected dysphonia will be present. Bilateral paralysis, in which the vocal cords remain in the cadaveric position, produces complete aphonia. Patients suffering from unilateral adductor paralysis of the recurrent laryngeal nerve derive considerable benefit from speech therapy.

Treatment consists of exercises to induce the healthy cord to overstep the midline and approximate with the immobile cord, thus producing a closure of the glottis. Breathing exercises are also helpful because such patients tend to inhale in short gasps. *Treatment of unilateral paralysis*

Treatment of bilateral paralysis

The treatment of cases of bilateral paralysis requires considerable experience on the part of the speech therapist. Careless or unskilled handling can easily cause serious effects Whilst aiming at establishing control in the movement of the vocal cords, the danger of bringing about a permanent closure of the glottis, and thus endangering the patient's life, must always be borne in mind. Nevertheless, under skilled treatment a considerable degree of control can be established.

BIBLIOGRAPHY

Goldstein, K. (1942). *After Effects of Brain Injuries in War their evaluation and treatment, the application of psychologic methods in the clinic.* New York; Grune and Stratton

Granich, L. (1947). *Aphasia a guide to retraining*. New York; Grune and Stratton

Head, H (1926). *Aphasia and Kindred Disorders of Speech* 2 vols. London; Cambridge University Press

Morley, Muriel E. (1945). *Cleft Palate and Speech.* Edinburgh; Livingstone.

Negus, V. E. (1929). *The Mechanism of the Larynx.* London; Heinemann.

Stein, L. (1942) *Speech and Voice* London, Methuen

Thal, Joan H van (1934) *Cleft Palate and Speech.* London; Allen and Unwin.

Weisenburg, T., and McBride, Katherine E (1935) *Aphasia. a clinical and psychological study.* New York; Commonwealth Fund.

West, R, Kennedy, L., and Carr, Anna (1947). *The Rehabilitation of Speech.* New York; Harper.

[References to other titles are given under Speech Therapy in the Index Volume]

SPINAL COLUMN

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PART I
TUBERCULOSIS OF THE SPINE

1. INTRODUCTION

306.] It has frequently been said that tuberculosis of bones and joints is a local manifestation of a general condition, and in considering the treatment of tuberculosis of the spine, this fact must constantly be kept in mind.

2. AETIOLOGY

The mycobacterium of tuberculosis may be of the human or bovine type, and may gain access to the body through the lungs, in infected milk or by *Mode of entry*

direct implantation. In the past it has been generally agreed that in young children infection is most commonly due to the bovine type. With the more general pasteurization of milk the proportion due to this type has been decreased.

3. MORBID ANATOMY

The bacilli infect lymphatic glands and from them are carried by the blood stream to different parts of the body. When the spine is affected the infection usually occurs first in the bodies of one or more vertebrae. Later the intervertebral discs are involved and the destructive process may spread to adjacent vertebrae. It is rare for a patient to be seen in the stage when only one vertebra is affected. The disease may occasionally occur in the laminae or in a spinous process or in an intervertebral joint.

FIG. 298.—Skiagram showing typical paravertebral abscess

4. CLINICAL SIGNS AND SYMPTOMS

In the early stage the patient seeking medical advice usually looks ill, for he is suffering from a general infection. The clinical signs and symptoms are, as a rule, the appearance of ill health with some general wasting; localized rigidity of the spine, due to muscle spasm with pain on movement which the patient sometimes instinctively minimizes by supporting the affected part by the use of his arms and hands; a deformity of the spine—kyphosis—which may or may not be present; abscess formation; bone destruction, in connexion with which the presence of an abscess may be demonstrated by radiological examination (Fig. 298) (tomographs are valuable in assessing the degree of bony involvement); and a raised sedimentation rate.

Localized rigidity

Deformity

If these signs are all present there is strong evidence in support of the diagnosis of tuberculosis, but the diagnosis is completely established only if, in pus obtained from an abscess, the mycobacterium of tuberculosis is found, or if a guinea-pig inoculated with this pus develops tuberculosis. The presence of an abscess may be one of the first signs of tuberculosis, particularly when the sacro-iliac joint is affected. The Mantoux test is of value, especially if the result is negative.

Mantoux test

5. DIFFERENTIAL DIAGNOSIS

Tuberculosis of the spine has to be differentiated from a number of other conditions, the most easily confused being osteomyelitis. The symptoms of *Osteomyelitis* this condition are usually more acute; they may respond to treatment by penicillin and usually they settle down much more quickly. In osteomyelitis there is seldom, if ever, any radiological sign of an abscess, and new bone formation may be seen at a relatively early stage. Leucocytosis is usually *Leucocytosis* present.

Of other conditions which have to be excluded the most important are primary and secondary tumours of the spine and senile osteoporosis with *Tumours* *Osteoporosis* secondary wedging and collapse of vertebrae.

6. TREATMENT

As tuberculosis is both a local and a general condition, its treatment must be both local and general and should be primarily conservative. By conservative, is meant the adoption of all methods to improve the general health, to increase the powers of resistance to tuberculous disease and to preserve or restore the parts affected. Conservative treatment may therefore include operative treatment.

(1) General

General treatment is of the utmost importance and involves consideration not only of the diseased area but of the patient as an entity. It is now fully recognized that, as in pulmonary tuberculosis so in surgical tuberculosis, treatment in the open air is of the greatest value, for, by this means, the *Open-air treatment* general well-being of the patient can be improved. In order that he may have the best chances of recovery he should be treated in an open-air ward in a hospital situated in the country away from the smoke of the town and dealing with orthopaedic conditions. If there is a pulmonary complication then the *Pulmonary complication* patient should be treated in a sanatorium. To get the full benefit from the open air the body should be exposed regularly to the sun and air, though an exception to exposure to the sun must be made for fair-skinned or red-haired patients who do not tolerate it well. Every patient, however, has to become acclimatized to open-air conditions and it is essential that this process should be carried out gradually. Exposure to the sun should be commenced in the early mornings, when its rays are not so hot as later in the day. Starting with a small area, stage by stage this is increased until the whole body is exposed. As part of the general treatment a good balanced diet with *Diet* ample vitamins is essential. Protein hydrolysate sometimes improves the general condition. While the physical treatment of the patient is carefully looked after, it is necessary to consider his mental condition and so to *Mental factors* prevent that depression which is apt to occur. Congenial occupation is necessary; occupational therapy, a hospital library, films and lectures are all of importance.

The work of the almoner too is valuable. With the almoner a patient
discuss any p
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and on his ch

should visit the hospital to see his patient, thus gaining a correct knowledge of the progress being made and maintaining his interest in his patient.

Chemotherapy

Streptomycin Included in general treatment, which aims at improving the well-being of the patient as a whole, is treatment by streptomycin, 1 gramme daily by injection, and *para*-aminosalicylic acid, 20–30 grammes daily by mouth. Both these substances have definite value in the treatment of tuberculosis. Streptomycin has certain toxic effects and streptomycin-resistant strains of tubercle bacilli may develop. It has been found that sulphetrone and streptomycin are more effective when used in combination.

Though streptomycin and *para*-aminosalicylic acid are both being used in the treatment of tuberculosis, insufficient work has been done accurately to assess the value of these drugs. If they are successful, they may revolutionize the treatment of tuberculosis. Other drugs are also being used experimentally.

(2) Local

Abscesses

Sites In tuberculosis of the spine an abscess is practically always present and can usually be seen in the skiagram. If the disease is in the upper cervical region of the spine a retropharyngeal abscess may occur. In the lumbar region a psoas abscess following the sheaths of the psoas muscle and pointing in the upper part of the thigh or iliac fossa may be present. Abscesses may track in any direction following fascial planes.

Aspiration For diagnostic purposes the aspiration of abscesses and the examination of the pus is very important. Apart from this they should be aspirated only if they are large or if it is thought they are about to break down. When aspiration is carried out it is necessary for the needle to be introduced into the abscess cavity through a valvular opening which will seal itself when the needle is withdrawn. *Risk of rupture* In the case of a retropharyngeal abscess the risk of rupture into the pharynx must be avoided. The abscess should be aspirated from the side of the neck, access to it being obtained by inserting a needle behind the posterior margin of the sternomastoid muscle.

(3) Immobilization

Plaster beds The essential special surgical treatment of tuberculosis of the spine is immobilization. Many methods have been used to ensure this, and jackets of varying types, plaster beds and frames are all utilized by different surgeons (*see* Beds, Plaster, Vol. 2, p. 54). If considerable deformity is present a plaster-of-Paris bed is the most useful and can be made so as to avoid pressure over the kyphosis. For the routine treatment of the average case the Jones straight frame is quite satisfactory. It requires, however, special skill and experience in its use. Each frame should be made to measure for the individual patient.

(a) Jones frame

[illegible] specially

[illegible] mb's-

[illegible] has

wool. Sometimes instead of the saddle Sorbo rubber is used. [illegible] side bars of malleable iron, two on each side, one at the nipple line and one at the anterior superior iliac spine, and they must be moulded to the chest and

pelvis so as to limit lateral movement. If the frame is to be used for a lesion between and including the mid-dorsal area and sacro-iliac joints, it should reach from the lower cervical region to $1\frac{1}{2}$ inches above the internal malleolus. If the lesion is above the mid-dorsal region, the frame has to be lengthened by means of a flat head-piece on which the head rests (Fig 299). When the upper dorsal or cervical region is involved, a sunken head-piece is required; into this the head fits, and movement of the cervical spine is therefore, to a certain extent, limited. The main object of the frame is not to correct the *Moulding to limit movement*

FIG. 299 —Jones straight frame with head-piece for mid-dorsal tuberculosis

deformity but to immobilize the spine for a period long enough for the disease to settle down and for consolidation to take place. Apparent correction of the deformity sometimes occurs, but this correction is produced usually by hyperextending the spine above and below the affected area. In this way the kyphosis is masked but not eliminated. There is, however, improvement in the general appearance and balance of the body.

(*b*) *Turning case*

All patients treated on the Jones frame need plaster turning cases. These are made in such a way that they can be strapped on the patient and frame before turning When turned, the frame is removed and the patient lies on the turning case so that his back can be examined and the skin treated if necessary.

(*c*) *Duration of immobilization*

Immobilization should be continued until it is judged that the condition has become quiescent or until progress has been arrested. This is indicated by the absence of muscle spasm and of pain, a reduction in size of the abscess, by the radiological appearances of the affected area, by calcification of a residual abscess, by the return of the sedimentation rate to normal, by an increase in weight and by a general improvement in health Adult patients should be immobilized in an open-air hospital for at least 12 months, and for children the necessary period is longer. Sometimes, however, the elderly patient is allowed to discontinue immobilization at an early stage provided the x-ray appearances and the general condition warrant it. *Indications of progress*

(4) Surgical fixation of the spine

(*a*) *Splintage*

Whether a grafting operation has or has not been performed, a spinal support will be required for a time when the patient becomes ambulant. The

Jones posterior spinal support

support may be one of varying types. A very effective splint for reducing, though not completely preventing, antero-posterior movement is the Jones posterior spinal support. It consists of a malleable-iron frame covered with leather and is moulded to the patient's spine. It is used in all cases, but if the lesion is in the upper dorsal region a collar is added, and if the cervical spine is affected a moulded doll's collar is required (Figs. 300 and 301). The

FIG 300.—Jones posterior spinal support with collar, for tuberculosis of mid-dorsal and upper dorsal vertebrae

FIG 301.—Jones posterior spinal support fitted with patient lying When fitted the support should touch the whole of the lumbar and lower dorsal region of the spine, but should stand away from the upper dorsal region.

posterior spinal support is not really effective when a lateral deformity has occurred, because it does not limit lateral movement. It is then better replaced by a leather jacket. If either of the sacro-iliac joints or if the lower lumbar region is involved, a short leather spica is the best method of immobilization.

Leather jacket

Duration of support

The support should be worn for not less than 12 months in every case, but in children for a longer period. If the bodies of the vertebrae are fused then the splint can be safely left off. As a rule, it is wise to use the support for most of the growing period in children.

(*b*) *Bone grafting*

In general it can be said that fusion of the laminae by bone grafts gives added security which limits the risk of recurrence. There are, however, some factors, such as the presence of abscesses, the condition of the skin and

sometimes the age and condition of the patient, which preclude operation. In children in whom the disease takes longer to become quiescent, it is considered that a graft, even if successful, may delay recovery by holding apart vertebral bodies which if left alone would have collapsed and consolidated. In general it should be said that the average adult patient should have a bone-grafting operation, but in the average case in childhood operative treatment is not required. In no case should the operation be performed until a relatively quiescent stage is reached.

Technique.—The operation may be carried out in several different ways. The simplest of all is to expose the laminae, to make the surface raw by chisel and rasp, to turn down fragments of bone and to place grafts taken from the tibia on the raw areas so made. The length of graft will vary with the area involved, but it should extend, at the minimum, from one normal vertebra above to one normal vertebra below the affected area. It is important that the graft should be correctly placed. This can be ensured pre-operatively by marking a spinous process by a small metal nail and then taking a radiograph. A simple but effective method is to place a short length of Cramer wire splinting over the spine and take a skiagram. From this it can be seen which strand of wire corresponds to the centre of the deformity and its position marked on the skin with methylene blue or some other dye which can be seen when the skin incision is made. If there is a severe kyphotic deformity the prominent spinous processes should be excised. This adds to the subsequent comfort of the patient and improves the appearance.

Length of graft

Cramer wire splinting

After the grafting operation the spine should be immobilized for a further 2–3 months before the patient is allowed to get up in a spinal support.

7. COMPLICATIONS

(1) Paraplegia

Paraplegia may be a serious complication of tuberculosis of the spine and may occur in the early stages of the disease or later, when the disease has apparently become quiescent. When it occurs in the early stage the first signs are spasticity with inco-ordination of action, and there may be general flexor spasm of the muscles of the lower limbs leading later to a flaccid paralysis.

Signs

Paraplegia may be caused in the early stage of disease by pressure of an abscess or granulation tissue, or by secondary vascular or toxic reactions in the cord due to the neighbouring active tuberculosis.

Very rarely it may be caused by pressure of bone. In the later stages it may result from renewed activity of the disease.

Treatment

This complication of tuberculosis is not very common. In the less severe and early cases when the spine is immobilized the paraplegic symptoms usually subside, but if this does not take place or if they increase it may be necessary to operate in order to remove pressure. In that case one of two operations can be performed, either a costo-transversectomy or a laminectomy, the choice depending on the site of disease and the presumed cause of paraplegia. When it is thought to be due to pressure by an abscess or granulation tissue a costo-transversectomy is usually required. At this operation the posterior part of a rib at the required level is excised together with the adjacent

Indications for operation

Costo-transversectomy

transverse process, and access is obtained to the part of the vertebrae affected and the abscess evacuated. In the very rare cases in which the paraplegia is caused by the deformity of bone, a laminectomy is needed. The removed laminae are replaced by a bone graft to counteract the weakness of the spine.

Laminectomy

Fortunately, however, severe paraplegia requiring any special treatment is, in our experience, rare. Of 257 cases of tuberculosis of the spine treated at Harlow Wood Orthopaedic Hospital in the period 1929–49, only 14 showed any signs of paraplegia. In 13 cases the symptoms were slight and responded to the ordinary treatment of immobilization. Only one, a late case, required costo-transversectomy; in this case there was a complete recovery after the removal of a bony prominence causing pressure on the cord.

(2) Complications of recumbency

Recumbency in itself leads to certain complications. These are renal calculi; pressure sores; and deformity of the legs and feet.

(*a*) *Renal calculi*

Causative factors

The formation of renal calculi is not a common complication. It is due to several factors, such as dehydration of the body, which may occur as a result of water loss by exposure to the sun; stagnation of fluid in the pelvis of the kidney due to inadequate drainage caused by the supine position of the patient; and to excess excretion of calcium resulting from disuse.

Prophylaxis

The risk of the formation of renal calculi is reduced by regular tilting of the bed, so as to maintain drainage, by insisting upon adequate intake of fluids to make up for loss in hot weather, and by avoidance of excessive administration of vitamins in the summer.

The presence of a calculus should be suspected, even if not seen in the skiagram of the renal tract, if transient haematuria develops after turning the patient to inspect his back, which has to be done regularly. The calculus of calcium phosphate usually disappears rapidly when the erect position is again assumed.

(*b*) *Pressure sores*

Pressure sores are, unfortunately, likely to occur in very thin patients, in those in whom there is a marked kyphotic deformity or in those suffering from paraplegia. Careful padding of the frame or plaster bed, whichever is used, and careful attention to the skin, minimize the risk of these sores.

(*c*) *Deformities of the legs and feet*

Knee support

Prolonged immobilization may cause considerable muscular wasting and laxity of ligaments. Careful attention to the position and support of the knees to prevent a knock-knee deformity, subluxation of the tibia or a genu recurvatum is necessary.

Daily exercises and protection of the feet are required to prevent dropping of the foreparts and contracture of the plantar fasciae and the development of a calcaneum deformity which may otherwise occur.

(3) Development of a secondary lesion

Though not strictly a complication of tuberculosis the development of a secondary lesion is a possibility to be remembered.

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(3) Development of a secondary lesion

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Sometimes, while the tuberculous lesion in one part of the spine is becoming quiescent, another may develop. Great care, therefore, has to be taken not to disregard any complaint of pain in other parts of the spine or any physical sign suggesting it, for such ■ complication naturally affects the type and length of treatment. These lesions, as a rule, develop silently. They may also occur in the hip joint, in which case the pain may be referred to the knee. *Pain*

8. TUBERCULOSIS OF THE SACRO-ILIAC JOINTS

The treatment of tuberculosis of the sacro-iliac joints is the same as for the spine similarly affected. The prognosis is good, operative fusion is, as a rule, not necessary.

9. CONCLUSION

Treatment of tuberculosis of the spine involves general and special treatment. General treatment is best given in the open air of a country orthopaedic hospital. It consists of complete and continuous immobilization of the spine on a special frame or plaster bed, followed by internal or external fixation or both. In the average adult case a spine-grafting operation is necessary and advisable, but this should not, as a rule, be done for children. The best method of dealing with tuberculosis, and the only real answer, is to prevent it. The results of treatment are satisfactory on the whole and patients may ultimately find themselves able to live practically normal lives.

PART II
SCOLIOSIS

transverse process, and access is obtained to the part of the vertebrae affected and the abscess evacuated. In the very rare cases in which the paraplegia is caused by the deformity of bone, a laminectomy is needed. The removed laminae are replaced by a bone graft to counteract the weakness of the spine.

Laminectomy

Fortunately, however, severe paraplegia requiring any special treatment is, in our experience, rare. Of 257 cases of tuberculosis of the spine treated at Harlow Wood Orthopaedic Hospital in the period 1929–49, only 14 showed any signs of paraplegia. In 13 cases the symptoms were slight and responded to the ordinary treatment of immobilization. Only one, a late case, required costo-transversectomy; in this case there was a complete recovery after the removal of a bony prominence causing pressure on the cord.

(2) Complications of recumbency

Recumbency in itself leads to certain complications. These are renal calculi; pressure sores; and deformity of the legs and feet.

(a) *Renal calculi*

Causative factors

The formation of renal calculi is not a common complication. It is due to several factors, such as dehydration of the body, which may occur as a result of water loss by exposure to the sun; stagnation of fluid in the pelvis of the kidney due to inadequate drainage caused by the supine position of the patient; and to excess excretion of calcium resulting from disuse.

Prophylaxis

The risk of the formation of renal calculi is reduced by regular tilting of the bed, so as to maintain drainage, by insisting upon adequate intake of fluids to make up for loss in hot weather, and by avoidance of excessive administration of vitamins in the summer.

The presence of a calculus should be suspected, even if not seen in the skiagram of the renal tract, if transient haematuria develops after turning the patient to inspect his back, which has to be done regularly. The calculus of calcium phosphate usually disappears rapidly when the erect position is again assumed.

(b) *Pressure sores*

Pressure sores are, unfortunately, likely to occur in very thin patients, in those in whom there is a marked kyphotic deformity or in those suffering from paraplegia. Careful padding of the frame or plaster bed, whichever is used, and careful attention to the skin, minimize the risk of these sores.

(c) *Deformities of the legs and feet*

Knee support

Prolonged immobilization may cause considerable muscular wasting and laxity of ligaments. Careful attention to the position and support of the knees to prevent a knock-knee deformity, subluxation of the tibia or a genu recurvatum is necessary.

Daily exercises and protection of the feet are required to prevent dropping of the foreparts and contracture of the plantar fasciae and the development of a calcaneum deformity which may otherwise occur.

(3) Development of a secondary lesion

Though not strictly a complication of tuberculosis the development of a secondary lesion is a possibility to be remembered.

Sometimes, while the tuberculous lesion in one part of the spine is becoming quiescent, another may develop. Great care, therefore, has to be taken not to disregard any complaint of pain in other parts of the spine or any physical sign suggesting it, for such a complication naturally affects the type and length of treatment. These lesions, as a rule, develop silently. They may also occur in the hip joint, in which case the pain may be referred to the knee. *Pain*

8. TUBERCULOSIS OF THE SACRO-ILIAC JOINTS

The treatment of tuberculosis of the sacro-iliac joints is the same as for the spine similarly affected. The prognosis is good, operative fusion is, as a rule, not necessary.

9. CONCLUSION

Treatment of tuberculosis of the spine involves general and special treatment. General treatment is best given in the open air of a country orthopaedic hospital. It consists of complete and continuous immobilization of the spine on a special frame or plaster bed, followed by internal or external fixation or both. In the average adult case a spine-grafting operation is necessary and advisable, but this should not, as a rule, be done for children. The best method of dealing with tuberculosis, and the only real answer, is to prevent it. The results of treatment are satisfactory on the whole and patients may ultimately find themselves able to live practically normal lives.

PART II
SCOLIOSIS

KYPHOSIS

1. DEFINITION

Scoliosis is the condition in which the spine, when the erect posture is assumed, deviates either to one or other side or to both sides. It is divided into two groups—postural and structural. This article is concerned only with structural scoliosis in which there is a lateral curvature of the spine with a greater or less degree of rotation of vertebrae.

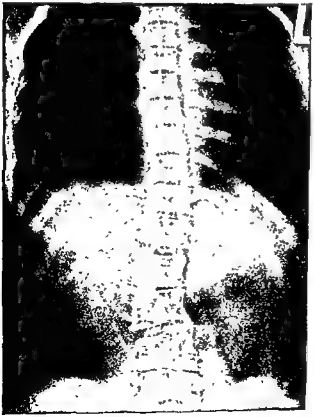


FIG. 302.—Congenital scoliosis. Compensation by symmetrical hemivertebrae.

2. CAUSATION

Classification of causes

Structural scoliosis may be caused by any of the following:

(1) Congenital defects: wedged vertebrae, fused ribs, spina bifida.

(2) Softening of bones and laxity of ligaments, due to rickets, osteomalacia, inflammatory conditions of bone.

(3) Injury.

(4) Alteration of muscle balance, due to infantile paralysis, syringomyelia, Friedreich's ataxia, myopathies.

(5) Idiopathic causes.

(6) Alteration in the symmetry of the trunk secondary to chronic empyema, pulmonary tuberculosis or severe burns.

(7) Other congenital and acquired deformities: torticollis, Sprengel's shoulder, paralysis of the shoulder muscles, ocular and aural defects.

(8) Alteration of the level of the pelvis due to shortening of one lower limb, unreduced congenital dislocation or a fixed adduction deformity of the hip.

(9) Sciatica.

(10) Hysteria.

FIG. 303 — Congenital scoliosis Showing fusion of ribs preventing expansion of one side of the chest.

(1) Congenital defect of the bone

In the group due to this defect the most common cause of scoliosis is wedged vertebrae, often associated with a hemivertebra (Fig. 302). This deformity is usually first noticed shortly after birth and may change little during growth. It is sometimes associated with fused ribs (Fig. 303). Spina bifida may also be present (Fig. 304). *Wedged vertebrae*

FIG. 304 — Cervical and upper dorsal spina bifida with associated scoliosis

(2) Softening of bones and laxity of ligaments

Advanced rickets is now an uncommon disease and the wedging of the vertebrae which may accompany it is therefore rarely seen. Senile osteomalacia usually leads to a kyphotic deformity but may cause a lateral curve. Tuberculosis of the spine may rarely involve chiefly one side of the vertebral bodies causing a lateral deviation. *Osteomalacia* *Tuberculosis*

(3) Injury

A compression fracture of the body of a vertebra if chiefly on one side may cause scoliosis.

(4) Alteration of muscle balance

This may be due to poliomyelitis, certain diseases of the central nervous system and certain myopathies. Of these causes the most common is *Anterior poliomyelitis*

muscles on each side are equally affected, the spine may sag and concertina into itself, so producing an antero-posterior or a lateral curve or both. As the paralysis is seldom symmetrical, however, a lateral curve usually results with rotation of the vertebrae.

(5) Idiopathic causes

Idiopathic scoliosis (Fig. 305) is the term given to scoliosis occurring in childhood without known cause and with gradual progression. The condition may be due to a mild attack of infantile paralysis which passes almost

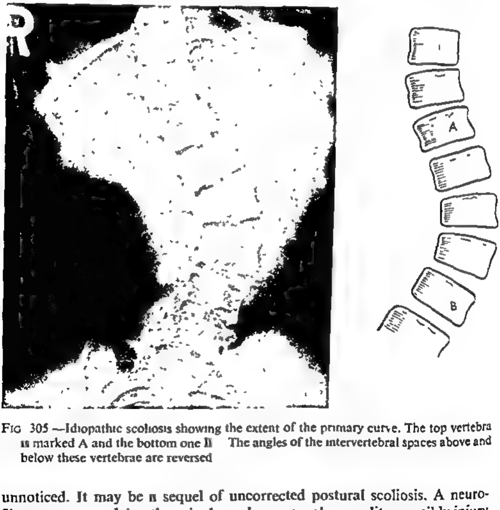


FIG 305 —Idiopathic scoliosis showing the extent of the primary curve. The top vertebra is marked A and the bottom one B The angles of the intervertebral spaces above and below these vertebrae are reversed

unnoticed. It may be a sequel of uncorrected postural scoliosis. A neurofibromatosis involving the spinal canal or some abnormality, possibly injury of an intervertebral disc, may be the cause. It is a condition still requiring careful investigation.

(6) Alterations of the symmetry of the trunk

Chronic empyema or operative treatment for certain chest conditions may cause marked deformity of the chest. A lack of expansion on one side may then result in a lateral deviation of the spine. Severe burns may produce contracture of one side of the chest or body and so cause scoliosis.

Burns

(7) Other congenital and acquired deformities

If a marked and untreated torticollis is present the attempt to maintain the head in the correct position will cause a curvature of the spine in the cervical region. Sprengel's shoulder and paralysis of the muscles of the shoulder girdle may, by the effort required to make the weakened arm function normally, produce a lateral deformity of the spine. *Torticollis*

Ocular and aural defects may also cause a curvature which in time may become structural.

(8) Alterations in the level of the pelvis

This may be produced by the shortening of one leg or by an unreduced congenital dislocation of the hip, but a secondary fixed scoliosis does not necessarily develop. It may be caused by a fixed adduction deformity of one hip.

(9) Sciatica

When this is due to an intervertebral disc lesion, sometimes a tilting of the body away from the side affected occurs. This may be an involuntary attempt to prevent stretching of the lumbo-sacral trunk. It may appear to be, but it is not, a structural deformity.

(10) Hysteria

Scoliosis of the hysterical type is due to patients assuming some particular posture for which there is no organic cause.

3. CLINICAL PICTURE

The condition is usually noticed first in childhood when the parents may observe that the child's chest is deformed or that one hip is more prominent than the other. Even with a marked deformity, patients complain mainly not of pain but of the deformity, though in the later stages, if the condition has been allowed to progress, patients of middle age sometimes have pain and tenderness at the side where the ribs and iliac crest overlap. At any age there may be a complaint of becoming unduly tired after exertion.

There is, as a rule, no doubt about the presence of even moderate structural scoliosis if the patient is completely stripped for examination. The deformity caused by rotation of vertebrae may not be very obvious when the patient is standing upright, but when the spine is flexed, if the dorsal region is involved, the asymmetry of the chest is at once seen. If the condition is due to infantile paralysis the curve may not be fixed in the early stages, and then it can be almost completely corrected by suspension. The diagnosis is confirmed by antero-posterior and lateral skiagrams taken in the lying and standing positions. An additional antero-posterior view with the spine passively extended by head traction is necessary. *Examination of flexed spine*

4. MEASUREMENT OF THE DEFORMITY

Much discussion has taken place about primary and secondary curves. In general it can be said that the primary curve is the one which is least susceptible of correction; if there are three curves it is usually the middle one.

Various methods are used for measuring the deformity. First the top and bottom vertebrae of the main curve have to be identified. This is done by

Radiography

observing in the radiograph the vertebrae which have the wedging of the intervertebral spaces above and below them pointing in opposite directions (Fig. 305). At these points the curves are changing from convex to concave or *vice versa*. A line at right angles to the top vertebra and one at right angles to the bottom vertebra of a curve make an angle and this angle can be regarded as the angle of the curvature.

If a fixed secondary lumbar curve is present, it will be partially or fully corrected by raising the pelvis on the convex side of this curve when sitting; the angle of the residual curve, if still present, can then be measured on a skiagram of the spine taken while the patient is seated. Similarly a secondary dorsal curve can be measured if, while lying, the patient's spine is flexed to the convex side of this curve as much as possible and a skiagram taken.

5. TREATMENT

Probably few orthopaedic problems are more baffling than the treatment of scoliosis in the fully developed case. Consequently in this, as in so many other conditions, the best treatment is prevention.

The research committee of the American Orthopaedic Association in 1941 made a report on the results of treatment of 425 cases of idiopathic scoliosis; some of their conclusions, with which there would be general agreement, are summarized below:

Summary of results

(1) Practically no cases were cured.

(2) In 40 per cent of those treated by exercises, the deformity remained unchanged, in 60 per cent it increased.

(3) In the majority of cases correction without fusion was all lost after supports were discontinued.

The treatment of scoliosis consists of the treatment of the cause when possible, and the prevention and treatment of the deformity and symptoms. The treatment of the various causes does not come within the scope of this article.

Prevention of secondary curves

In the majority of instances scoliosis, apart from the congenital type, comes on insidiously; therefore great care is required to detect and prevent its development in the early stages and great attention to the posture of the body at all ages is very important. If congenital defects are present little can be done except to prevent secondary deforming curves from occurring and to develop the muscles by special exercises. Sometimes a plaster bed is helpful in assisting a child to adopt a correct position when at rest. If poliomyelitis is present or suspected, it is of the utmost importance at once to support or guard the affected muscles. Early postural defects, too, should be taken seriously for when once rotation of the vertebrae with a resulting C curve has developed, then only prolonged and arduous treatment is of any value.

The object of treatment in scoliosis is first to correct the deformity as much as possible and then to maintain the correction.

Postural exercises

In mild cases, postural exercises to develop the weakened muscles and support them, and rest of these muscles to prevent undue strain, are needed. When a structural defect is pronounced much more radical methods are required. The aim of these methods must be either to correct the curvature itself or to develop such secondary curves as will compensate for the primary curve and enable the spine to be held in equilibrium by muscular action.

Clearly, however, this is impossible when the potential musculature necessary is not present and so cannot be developed. In these cases therefore, having corrected the deformity as much as possible, the choice is between fusion of the affected part of the spine and the use of a special spinal support.

(1) Methods of treatment

The methods at our disposal are: physiotherapy; plaster beds and exercises; roller beds and traction; plaster cases with traction; plaster cases with turnbuckles; spinal supports; and operative treatment.

(2) Physiotherapy

This is useful in all cases and aims at developing the muscular power of the spinal muscles. It may be all that is necessary, particularly in the milder types. In those patients in whom a slight curve is present but in whom structural changes are not marked, alternating rests and postural exercises may achieve a good result. These cases can be treated as out-patients though it is very important that they should have daily periods of rest.

If, in the rather more severe conditions in which there is a fixed deformity, a state of equilibrium can be obtained by muscular action, re-education exercises are often effective in preventing an increase in the deformity.

Patients not responding to out-patient treatment need the supervision and intensive treatment which only a hospital can provide.

(3) Plaster beds and exercises

Plaster beds are made on the patient in the prone position and should extend from the neck to just above the knees. The technical details of making these beds are described elsewhere (*see* Beds, Plaster, Vol. 2, p. 54). The bed when made exactly fits the patient's deformity, which can be partially corrected by filling-in the depression in the bed by felt pads gradually increased in thickness.

In the early stages of treatment the patient should lie on the bed when not doing exercises, but, as muscular power and control develop, he should be allowed to get up for longer periods until finally he only sleeps in the plaster bed. Although these beds are used as a method of treatment they are also used as a method for prevention of scoliosis, and this is probably their most important function. In cases of infantile paralysis the plaster bed prevents the paralysed muscles from over-stretching, while electrical stimulation and exercises are given over a prolonged period to re-educate and develop the muscles. Plaster beds are sometimes of value in cases of congenital scoliosis to prevent secondary deformities from occurring *Electrical stimulation*

(4) Roller beds

These are beds to which an attachment is added so that the patient can lie in an inclined position, the head being higher than the feet. The inclined portion of the bed is on rollers If traction is made on the head this is opposed by the weight of the body and a strong extension force is maintained on the spine The extension is best applied by means of a Crile's head-piece which normally is effective and well tolerated by patients. These beds are of great value when the deformity can be partially corrected by extension. Their object is to stretch contracted muscles and to rest those which are partially paralysed.

(5) Plaster jackets

These can be of many types, but those most commonly used are as follows.

(a) *Simple jacket*

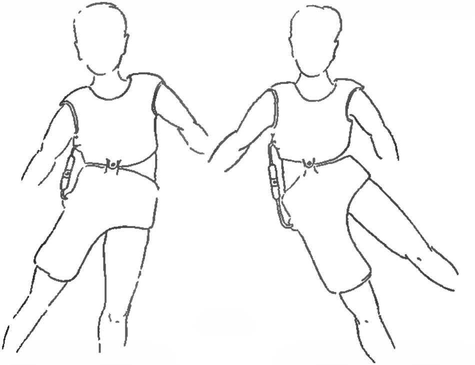
Special exercises

The simple jacket is applied with the spine in the position of maximum correction obtained by extension; manual correction of the deformity is carried out as the plaster sets. If the patient is to have special exercises, as is usually the case, a window may be cut in the jacket on the contracted side to allow expansion of the chest. Sometimes use is made of the iron lung to assist in this expansion.

(b) *Corrective jacket*

Risser jacket

This may be of the Risser or the Galeazzi type. The Risser jacket is applied with the patient in the supine position and should extend from the occiput and chin to the pelvis when a high dorsal curve is to be corrected and to the knee on one side if a lower curve is present. In the high curves the head



(a) (b)

FIG 306—Risser jacket for lower dorsal and upper lumbar scoliosis: (a) showing ellipse of plaster removed from the convex side; (b) showing turnbuckle extended with correction of the deformity.

should be tilted to the side of the concavity so as to reduce traction on the brachial plexus during correction of the deformity. As this is a forcible method of correction it is essential to assess beforehand the degree of the primary and secondary curves, for it is important not to attempt to correct the primary curve more than is necessary to balance the secondary curve. When dry the plaster cast is split horizontally at the point of maximum curvature; from the convex side an ellipse of plaster is removed and hinges are added in the midline with a turnbuckle on the concave side; as this

turnbuckle is screwed out, the body flexes to the opposite side and correction or compensation of the deformity should take place (Fig. 306). Sometimes it is found more convenient to make the jacket in two sections.

In the application of the Galeazzi jacket, special apparatus is required and the jacket is applied with the patient in the flexed position. These jackets depend for effectiveness on rigid mechanical means. The objection to them is that they require great skill and care in their application and subsequent management if pressure and other complications are to be avoided. *Galeazzi Jacket*

In some of the milder cases in the middle-aged or elderly pain is felt chiefly when a pronounced deformity causes overlapping of the ribs and iliac crest and considerably symptomatic relief can be obtained by a plaster jacket applied with traction to the head and neck; in such cases this should be finally replaced by a more permanent support.

(6) Operative correction of deformity

Operative treatment to correct the deformity is sometimes carried out. This may take the form of an operation to excise the hemivertebra or to excise projecting or fused ribs. This type of treatment does not receive general acceptance.

By one or other of the methods outlined, correction, usually only partial, may be obtained. Occasionally the muscle control may have been so well developed that no other support is needed. Occasionally, too, a compensatory curve is created which, if maintained, enables the body to be held in a position of equilibrium without undue strain on the supporting muscles. When the maximum correction has been obtained, if the patient is not able to hold this position unaided, assistance is needed. This may take the form of an external or internal splint.

(7) External splintage

This is achieved by means of a jacket made of various materials There are many who still consider that of all jackets, even with its disadvantages, that of moulded leather is the most useful. Certainly for durability without attention, over a prolonged period, a well-made and well-fitting leather jacket compares favourably with anything else. On the other hand, celluloid or plastic jackets are lighter and in some ways more comfortable. Whichever type of jacket is used, a cast has first to be made with the spine in the position of maximum correction and on this the jacket is built. Various forms of brace are also used, perhaps the best is the Taylor brace, but, like all supports and jackets, it leaves much to be desired *Leather jackets* *Taylor brace*

(8) Internal fixation

When is internal fixation needed? It is of value when compensatory curves cannot be maintained by muscular action, and it should be used therefore in the following conditions:

(1) When the position of the spine can be corrected by extension but the correction cannot be maintained by muscular action. In these cases internal fixation may obviate the necessity for permanent external support.

(2) When in congenital cases the condition is becoming progressively worse.

(3) *When only a partial correction of the deformity has been obtained.* A fusion operation assists in consolidating the gain in posture and in combination with a support may prevent a further increase in the deformity, though the strain imposed may be greater than the grafted area alone can take.

(a) Area to be fused

Choice of site The decision as to the area of the spine to be fused is not easy to make. One method found of value, particularly in cases due to infantile paralysis or in those in which there is fair mobility of the spine after treatment, is to let the patient stand and then observe how the spine extends on head suspension. As the suspension is released the upper and lower points at which the spine kinks are noted. The upper and lower limits of the spinal deformity can in this way be seen In the more rigid conditions and in those treated throughout in plaster jackets, this method is not applicable. In these cases the *general rule should be to fuse the primary curve, which is determined by* a study of the radiographs. When a decision as to the length of graft has been made the upper and lower limits should be marked on the skin with methylene blue or some similar dye which will be visible at the time of the operation.

(b) Fusion operation

Should the operation be carried out with the patient in a plaster jacket or not? The answer to this depends on the mobility of the spine. If the deformity can be largely corrected by traction a jacket is not necessary. This applies particularly to the cases due to infantile paralysis. *If, however, the maximum* correction can be obtained only by the use of a plaster jacket which is applied with head suspension, and in which manual correction has been used, then the operation should be done through a window. If the correction has been made by means of a Risser jacket, the operation should be done *through a window in the* jacket.

FIG 307.—Fusion of the spine by twin grafts This patient does not wear a support and practically no deformity is noticeable when standing.

(c) Methods of internal fixation

Neither the Hibbs nor the Albee operation for fusing the spine in scoliosis is entirely satisfactory. Technically, on account of the rotation of the vertebrae, the Hibbs operation is not easy, and the Albee operation to fuse the spinous processes in this condition is not mechanically sound. What is really needed is fusion of the laminae.

This can be achieved by

exposing the spinous processes and the laminae, by making the surfaces raw and by placing on them twin tibial grafts which can be bent or if necessary sectioned so as to accommodate them to the curve (Fig. 307). The grafts are in effect really a series of small grafts uniting the laminae to one another and therefore if it is necessary to section one in order to fit the curve, this is of no significance as far as the strength is concerned provided the break is on a lamina and not on an inter-laminal space. Iliac grafts are equally effective but the operation to provide enough iliac bone when a long area of fusion is required is formidable. *Fusion of laminae*

(d) Anaesthesia

The anaesthetic for the operation, particularly if a plaster jacket is used, should be given by the endotracheal method.

6. POST-OPERATIVE TREATMENT

This depends on whether or not a plaster jacket has been used during the operation and on the type of jacket. If the correction has been obtained by the Risser jacket, then the patient remains in it for about three months. If a simple suspension jacket has been used and the deformity is mainly in the dorsal region, then traction should be applied after operation and maintained for two or three months.

In the cases in which the deformity can be largely if not entirely corrected by traction post-operatively, the patient lies in a plaster bed and traction is applied to the head. *Traction*

Whichever method is used, after about three months a simple plaster jacket is applied and while in this the patient gets up. A more permanent jacket will normally be required for another nine months. At the end of that time assessment of the effect of the operation and a decision as to the necessity for further support can be made.

7. PARAPLEGIA

Paraplegia is a complication of scoliosis which may occur when there is a very marked curve of the spine. Few cases have been reported. It has been found that paraplegia has been relieved in some instances by traction on the spine but in others a laminectomy has been necessary, with section of the dura. In one reported case a tight membrane—probably congenital—crossing the dural canal from side to side has been found and divided, with relief of the symptoms of paraplegia (McKenzie and Dewar, 1949). *Treatment*

8. SUMMARY

The treatment of scoliosis can be said to consist of the use of exercises and plaster beds and correction of the deformity by special jackets followed by the application of internal or external fixation. Some cases due to congenital conditions need no corrective treatment but require supervision.

A variety of methods will produce an improvement in the less severe cases but there is no doubt that severe scoliosis is an extremely difficult condition to treat. It is therefore of great importance that all children attending school should be thoroughly examined so that incipient deformities may be observed in the early stages and treated.

KYPHOSIS

1. ADOLESCENT KYPHOSIS

(*See* Epiphyses—Diseases of, Vol. 3, p 449.)

In this condition wedging of the middle and lower dorsal vertebrae occurs. Sometimes the upper lumbar vertebrae are also involved.

(1) Pathology

Causation

The condition is generally considered to be due to an abnormality of the vertebral epiphyseal plates which may be caused by injury; it may be associated with short hamstring muscles, the presence of which may cause additional strain on the spine when this is forcibly flexed.

Radiographic recognition

Wedging of the vertebral bodies and narrowing of the intervertebral spaces with irregularity and fragmentation of the vertebral epiphyseal plates (Scheuermann's disease) can be recognized radiographically. Rounded protrusions into the intervertebral bodies due to herniation of the nucleus pulposus through the abnormal epiphyseal plates (Schmorl's nodes) may also be present.

(2) Symptoms

Occasionally there is pain but usually advice is sought on account of the deformity of the back.

(3) Treatment

Exercises

In the early stages treatment consists of postural exercises with daily rest periods. If the condition progresses or does not improve, or if pain is present, recumbency on a plaster bed is necessary. This bed should be made with the spine in the position of maximum correction and the correction steadily increased by the application of felt pads to fill in the hollow in the bed caused by the deformity. Exercises should be carried out during recumbency.

Treatment on the plaster bed should be continued for at least 4–6 months, depending on the progress made. After the patient is fit to get up and resume normal activities, it is advisable to sleep in the plaster bed and to wear a posterior support during the day until the risk of recurrence of the deformity is past. The time for this is decided by observing the effect of gradually discarding the support.

2. SENILE OSTEOPOROSIS

[illegible] A light [illegible]

3. ANKYLOSING SPONDYLITIS

The general treatment of this condition is referred to elsewhere. The kyphosis which develops should be treated by recumbency on a plaster bed. Radiotherapy, particularly if pain is present, may be of great value.

Radiotherapy

Spinal support

[illegible] has been obtained a spinal [illegible] he spine has fused. In cases [illegible] fused kyphosis, operative

correction of the deformity has been carried out and good results reported. This method of treatment is under trial (Herbert, 1948; Smith-Petersen, Larson and Anfranc, 1945). *Operative correction*

PART III
INJURIES OF THE SPINE

1. GENERAL CONSIDERATIONS

(1) Aetiology

Fractures of the vertebral column result from a variety of causes. The miner who, while in the stooping posture, is crushed by a fall of roof, the swimmer who dives into shallow water, the bricklayer who falls from a height either on his buttocks or on his heels, or the victim of a road accident, all may sustain fractures of the spine.

The most common type of injury is one which produces excessive flexion with a crushing of the anterior part of the body of the vertebra. A more severe injury may result in a dislocation of the intervertebral joints with damage to the nervous tissue in the vertebral canal. If more severe still, actual displacement of the vertebral fragments may occur, the more mobile segment moving forward on the more fixed element due to rupture of the ligaments of the vertebral arch. A sheering force may complicate the mechanism of this injury still further, causing forward, backward or lateral displacement. *Excessive flexion* *Displacement*

An extension type of injury, which is not common, causes a fracture of the vertebral arch and may be accompanied by a rupture of the anterior longitudinal ligament with detachment of a chip fragment from the inferior margin *Extension type of injury*

of the body. This occurs particularly in the presence of arthritis and may be associated with what appears to be disproportionate damage to the spinal cord. Lateral and rotational injuries frequently complicate the clinical picture and modify the site of fracture and displacement of the fragments.

(2) Surgical anatomy and mechanism

The vertebral column consists of an anterior component, comprising the vertebral bodies, intervertebral discs and the anterior and posterior longitudinal ligaments, and of a posterior component consisting of the vertebral arches together with the joints, ligaments and muscles attached to them. The intervertebral joints are large and vertically disposed in the thoracic and lumbar regions, and dislocations are less common than in the cervical region, where the articular facets are smaller and the superior facets are directed upwards as well as backwards. As a result, dislocation in the cervical region is more easily produced and reduction is less difficult than in the lumbar and thoracic regions. In the cervical region a combined flexion and rotation movement is possible and this, if forced beyond the normal range, may cause a lateral compression frequently associated with nerve-root pain referred to the upper limb of the same side.

Movement in the cervical region

Movement in the lumbar region

In the lumbar region the superior articular facets are convex, permitting lateral flexion and circumduction. Fractures resulting from excess of this movement are of the lateral marginal type.

Ligaments

The ligaments form important stabilizing factors. The ligamenta flava give elasticity and recoil. The interspinous and intertransverse ligaments give stability and, when ruptured, if there is also injury to the anterior component, make for an unstable spine in which, after manipulation, it is difficult to maintain reduction.

Muscles

The muscles of the posterior component limit the range of movement, and are themselves injured when bony and ligamentous damage occurs. Muscular contraction occasionally produces a fracture of a bony process. Fracture of the spinous process of the seventh cervical or first dorsal vertebra may occur with violent shoulder movements—the "clay-shoveller's fracture". Sudden contraction of the quadratus lumborum frequently causes fracture of one or more transverse processes of the lumbar vertebrae.

Laminae

The laminae in the lower lumbar region may show abnormalities of development. Mild trauma may then cause spondylolisthesis.

Intervertebral discs

The normal intervertebral disc is extremely resistant to injury and even if injured it is more likely that rupture of the numerous ligaments posteriorly and a fracture of the vertebral body anteriorly are the important lesions, especially when displacement occurs. In pathological states, however, the disc is more liable to prolapse and may then cause symptoms.

The condition formerly known as Kummel's disease is not now regarded as a clinical entity but as a result of an unrecognized injury of a vertebral body.

(3) Clinical picture

After a severe injury to the spine the patient at first suffers from shock, which may mask the physical signs. When the least movement occurs at the fracture site pain is acute, but may be referred to the extremities or to some

Pain

situation remote from the injury, as a result of involvement of the nerve roots.

Deformity is frequent, particularly in flexion injuries. In such cases, one spinous process, that of the injured vertebra, becomes prominent and forms a kyphos, and the interspinous interval between the spine of the injured vertebra and that of the spine of the vertebra immediately below is increased. Tenderness on palpation over the affected segment is usually present, with protective muscle spasm of the post-vertebral muscles. Swelling, bruising and restricted movements usually occur. *Deformity*

If the spinal cord is injured the clinical picture of fracture is overshadowed by profound changes in the reflexes, in sensation and in motor function.

Sometimes the clinical features of bone injury are few or even entirely absent, particularly in the hyperextension type of injury in the arthritic cervical spine, when extensive cord damage may be present without apparent injury to the adjacent tissues.

Skiagrams confirm the type of lesion and the disposition of the fragments. Lateral views give the most useful information and are very important. *Radiography*

(4) Treatment

The treatment of spinal injuries consists of the reduction of the fracture and fixation in plaster, with general and local exercises from the post-manipulative stage until complete recovery. As in other severe traumatic conditions, there is a marked catabolic process affecting the proteins in particular. A high protein diet, if necessary supplemented by protein hydrolysate, is of value in severe cases. In the cases in which reduction has not been obtained, as in lateral and rotational injuries, the patient is treated by rest and by graduated exercises, plaster fixation being unnecessary. The decision whether or not to operate in the early stages of treatment is frequently a difficult one to make. An injury which causes a fracture-dislocation with immediate paralysis almost invariably causes cord damage beyond surgical aid. In very exceptional cases an acutely prolapsed disc may cause paralysis and can be relieved by operation, but this occurs so infrequently that the general prognosis remains extremely grave in all cases of paraplegia of immediate onset. *Diet*

(a) *Operation*

(i) *Closed fractures without involvement of the nervous system.*—For early treatment when fractures, because of locking of the articular facets, are irreducible by other means, open reduction or apophysectomy may be necessary, and occasionally must be supplemented by bone grafting. *Early treatment*

In cases of late unreduced fracture-dislocation, or redisplacement of un-united fractures of the spine, with painful post-traumatic arthritis or spondylolisthesis, an arthrodesis of the affected area is required. *Late treatment*

(ii) *Closed injuries with involvement of the nervous system.*—Recovery of the more proximal muscle groups occurs within a few days and the prognosis is good. Laminectomy is useful in late cases only when the paralysis is delayed in its onset or is gradually progressive. Laminectomy, either early or late, is only rarely necessary, as, in the early case, a force sufficiently severe to fracture both components of the vertebral column and to produce immediate paralysis, will almost certainly irreparably damage the cord itself. *Early treatment*

Late treatment

Late laminectomy may be advisable in cases in which inadequate treatment is followed by a re-displacement and paresis, or in which there is compression due to callus formation or kyphosis.

(b) Rehabilitation

Physical

The rehabilitation of patients with spinal injuries is of prime importance and consists of local and general exercises as soon as the patient's condition will permit. When he is ambulatory and has discarded the plaster, exercises in a swimming-pool produce more rapid results than any other single form of therapy. Weight and pulley exercises are excellent when used in moderation and with other forms of activity. The mental aspect of rehabilitation primarily means a well-planned day in which the patient is fully occupied and has variety both in type of treatment and in his surroundings during treatment. Occupational therapy helps to provide this. Varying grades of work, up to log-cutting and heavy lifting, are required for the final stage of industrial rehabilitation. The social services of the almoner are most important in the early stages to free the patient from his outside worries, and in the later stages to form a contact between the patient and his ultimate employment.

Mental

(5) Prognosis

The prognosis of fractures of the spine is generally the prognosis of the complications. In the uncomplicated cases the vast majority return to full functional activity, but arthritis of the spine is liable to develop after some years, particularly if reduction has been incomplete. This arthritis gives rise to little disability except in workers in heavy industries.

Arthritis

2. CERVICAL SPINE

(1) Dislocations and flexion fractures

Sites

Traumatic dislocations, flexion fractures and fracture-dislocations result from similar causes and have so much in common in their treatment that they may be considered in one group. These injuries occur in the lower cervical region and, as Jefferson (1948) has stated, "at the point of maximum curvature under stress". When the dislocation is unilateral, a persistent torticollis deformity is present; when bilateral, the head appears to be pushed forward and there is much muscle spasm. If lateral wedging of the vertebral body is present, the pain is referred to the upper limb of the affected side. Paralysis of delayed onset is due to gradual forward displacement of the proximal segment or to haematoma formation, and the prognosis is better than in paralysis of immediate onset. All these dislocations and fractures are treated as emergencies.

Paralysis

Treatment

The patient with a dislocation is anaesthetized in the supine position and traction is applied through a halter or chin-strap which is fixed around the operator's waist, thus leaving both hands free for manipulation (Fig. 308). Powerful traction is applied and the head is gently moved to the contralateral side and lifted forwards into the slightly flexed position, then gently extended to allow the upper facet to fall back into place. A corresponding manoeuvre is performed on the opposite side to effect reduction of the

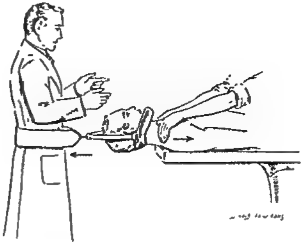


FIG 308.—Manipulative reduction by halter traction Note that both hands are free for manipulation.

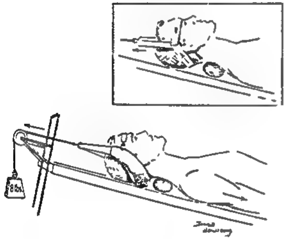
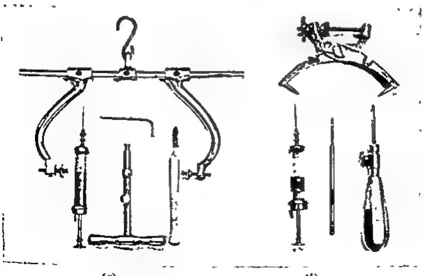


FIG. 309.—Traction applied to the occipital region by Crile's method Note there is no pressure on retentive forehead strap. (Inset mitre-type head-piece made from webbing and taking pressure on occiput and forehead)



(*a*) (*b*)

FIG. 310 —Apparatus for skull traction. (*a*) Blackburn, (*b*) Crutchfield.

second facet. When a crush fracture is present without dislocation, gentle traction and hyperextension will reduce the fracture; the reduction is maintained with a Crile's head-piece for a few days until the swelling subsides, when a plaster head-piece is applied.

Crile's head-piece

If this manipulation fails, or if it is inadvisable to administer a general anaesthetic, then a Crile's head-piece may be fitted and 8–10 pounds' traction applied (Fig. 309), with the head of the bed raised 6–8 inches on blocks. Alternatively, a mitre type of head-piece may be used for traction. If this method is found to be inadequate after a 24-hour trial period, skeletal traction will be necessary.

Crutchfield caliper

(i) *Skeletal traction.*—Skeletal traction is very powerful and may be applied through the parietal bones or through the zygomatic processes. The Crutchfield caliper (Fig. 310 (b)) is simple to insert and effective in action. The Blackburn pattern (Fig. 310 (a)) is rather stronger but is more difficult to adjust. Zygomatic traction is not mechanically sound, because the traction force is anterior to the optimal line of traction.

Application of caliper

The method of applying the caliper (Fig. 311) is simple and safe but care must be exercised when there is an abnormally thin skull. The skin is prepared and a suitable point is selected above and slightly behind the apex of each pinna. These symmetrically placed points are marked and infiltrated with 2 per cent Novocain and adrenaline. A small cruciate incision is made down to the outer table of the skull and the special trephine is applied to drill the outer table. When the diploe has been entered on each side the caliper points are introduced and securely fixed by a double screw locking device. A small dressing is applied and traction is commenced with 14–16 pounds over a pulley fixed to the head of the bed, which is suitably raised on blocks for counter-traction. A small firm pillow is placed behind the cervical spine to support it. The weight is increased gradually up to 30–40 pounds if necessary.

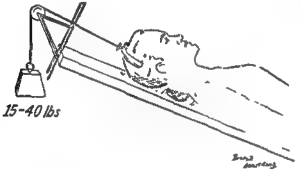


FIG. 311.—Crutchfield skull traction apparatus applied.

Manipulation

Reduction of the dislocation is frequently obtained spontaneously by this method in 24–48 hours, but if it does not take place a gentle manipulation under anaesthesia will be necessary. Once the dislocation is reduced, there is little tendency for re-displacement to occur, and the traction need be no more than 7–10 pounds to maintain position. In 2–3 weeks a plaster head-piece of the Minerva type replaces the traction and the patient is allowed up. The plaster is retained for 12 weeks, after which active exercises are commenced for the neck muscles, and a small supporting collar is applied. When the muscles are sufficiently strong to maintain position, the collar is discarded.

Minerva head-piece

(ii) *Operative reduction.*—Very occasionally the dislocation cannot be reduced by traction and manipulation, or re-displacement may occur. This is more liable to happen if the articular process is contused or fractured: in

either event reduction is obtained by open operation. After infiltration with adrenaline 1 : 200,000 in saline solution to limit haemorrhage, the affected vertebra is exposed through a midline incision. The articular facets are cleared and gentle traction on the head is applied by an assistant while the *Incision*

(a)

(b)

(c)

(d)

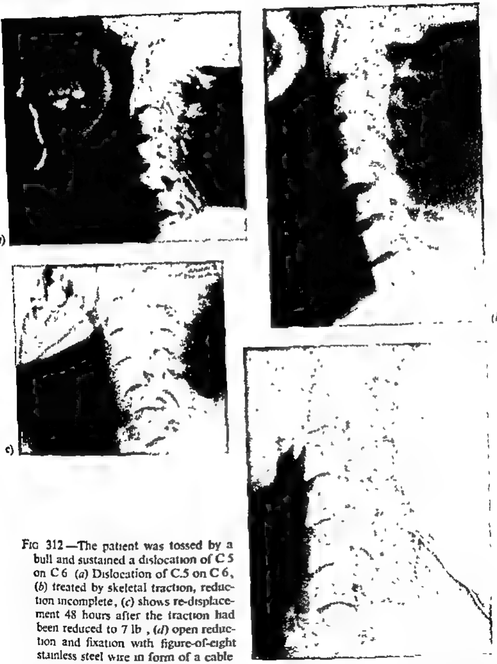
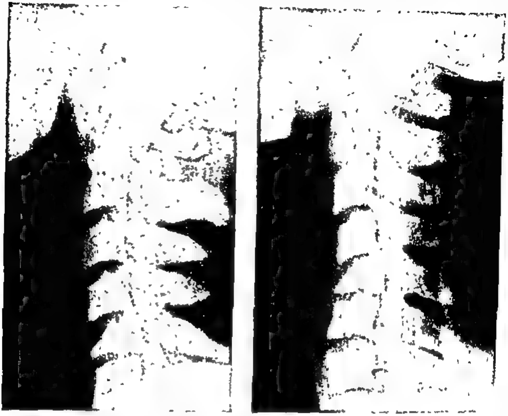


FIG 312—The patient was tossed by a bull and sustained a dislocation of C 5 on C 6 (*a*) Dislocation of C.5 on C 6, (*b*) treated by skeletal traction, reduction incomplete, (*c*) shows re-displacement 48 hours after the traction had been reduced to 7 lb , (*d*) open reduction and fixation with figure-of-eight stainless steel wire in form of a cable

forwardly displaced facet is reduced by gentle backward traction on the spinous process by means of tissue forceps. The reduction is maintained by a figure-of-eight wire around the spinous processes. The most suitable wire for this purpose is either braided tantalum or 6 strands of gauge 35 stainless-steel wire twisted to form a cable (Fig. 312).

If there is a recurrence of pain after a crush fracture or increasing wedging of the affected vertebra, a spinal fusion operation should be performed (Fig. 313). In some clinics the practice is to fuse all crush fractures in the cervical region because there is a saving of time, pain is less likely to occur

Spinal fusion



(a) (b)

FIG. 313.—Crush fracture of C 5 treated by spinal fusion: (a) fracture unstable due to wedging of vertebral body, (b) skiagram 6 months later, showing fusion by tibial grafts

and there is very little restriction of movement. There is much in favour of this procedure, especially after fracture-dislocations. The fusion is then performed 10–14 days after the injury.

(2) Spontaneous dislocation

Torticollis

Spontaneous or pathological dislocations of the atlas on the axis occur as a complication of tonsillitis, cervical adenitis and tuberculous disease of the upper cervical spine. The patient frequently has an acute torticollis deformity and, if he is walking when first seen, he will probably be supporting his head with both hands. These cases are a cause of sudden death, but that group which survives sufficiently long to come under treatment rarely presents signs of pressure on the central nervous system and responds well to treatment. X-ray examination confirms a forward displacement of the atlas on the axis and usually some tilting to one side (Fig. 314).

Abscess

A retropharyngeal abscess may be visible as a soft tissue swelling displacing the pharynx forward.

Treatment

Immediate relief is obtained on fixation by gentle traction and extension. The traction need not be great and can be applied through a Crile's head-piece in a manner similar to that already described for traumatic dislocations.

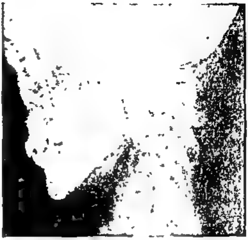


FIG. 314.—Spontaneous dislocation of the atlas following an attack of tonsillitis

The treatment of the causative factor should follow immediately, by aspiration or incision of the abscess, if present, and by the appropriate chemotherapy. Nursing care of pressure points over the occipital area is necessary and although no pressure should occur in the frontal area this part should be inspected regularly. It is advisable to continue traction for 6–8 weeks to permit the soft tissues to become adequately re-attached. A Minerva plaster is then applied to include the head and upper part of the trunk, to prevent rotation as well as flexion and extension of the cervical spine. This is continued for a further 2 or 3 months. Full function can be anticipated in these cases.

(3) Injury to the vertebral arch

Injury to the vertebral arch is caused by an extension-compression force which occurs when there is a fall on the vertex (Fig. 315). When a force is

FIG. 315.—Extension injury to the axis showing fracture of the vertebral arch

FIG. 316.—Extension injury showing fracture of the odontoid process with some backward displacement. Note also the arthritic changes in the cervical spine

transmitted through the lateral masses of the atlas the posterior arch may be split or, if the axis is involved, the odontoid process and the laminae may be fractured (Fig. 316). *Axis involvement*

Clay-shoveller's fracture

The spinous process of the seventh cervical vertebra may be fractured by muscular action—the clay-shoveller's fracture.

Treatment

The treatment of these injuries in the cervical region, where no displacement is present, is by fixation in plaster of Paris. If displacement is present, manipulation and traction are necessary. This traction should be continued for 3–4 weeks, after which plaster of Paris is applied, and this is required for 6–8 weeks. The subsequent treatment is similar to that for fractures of the vertebral body. Fractures of the spinous process usually heal by fibrous union and, with rest for a few weeks, the symptoms disappear. If they persist and are not relieved by local anaesthetic injection, excision of the separated fragment is necessary.

Excision

(4) Injuries complicated by arthritis

A minor injury, in patients who already have advanced osteoarthritis of the cervical spine without symptoms, may cause pain localized at first in the cervical region but radiating down one or both arms. These symptoms are often prolonged.

More severe injuries to the cervical spine are usually of the extension type. The radiograph may show nothing or only a chip fracture of the anterior vertebral margin, but there may be severe neurological signs, sometimes even complete quadriplegia with a very grave prognosis.

Quadriplegia

3. DORSAL SPINE

Incidence

Fractures of the dorsal spine occur twice as frequently as those of the cervical region and half as frequently as injuries to the lumbar spine. The most common lesion is a compression fracture of the vertebral body, resulting from excessive flexion of the column. A severe flexion injury, such as occurs in mining accidents with a fall of roof on the patient while he is in the crouching position, may cause cord damage. Alternatively this may occur in road accidents when a heavy wheel passes transversely across the back in the dorsal area, causing a fracture of the laminae, dislocation of intervertebral articulations and fractures of the vertebral body with forward displacement

Treatment

Treatment of a compression fracture of the vertebral body consists of reduction by hyperextension and fixation in a plaster jacket. The jacket maintains the hyperextended position by fixing the sternum and the pubis. It need not be above the inferior angle of the scapula posteriorly, as this permits of the more adequate development of the post-vertebral muscles. The plaster is maintained for approximately 8 weeks, during the whole of which time the patient is instructed in general and postural exercises.

Vertebral arch involvement

Fractures involving the vertebral arches in the dorsal region are rare except when complicating severe crush lesions. Isolated fractures of the vertebral arch without displacement are treated by a few weeks' rest in bed and by prone-lying extension exercises. Dislocation of the dorsal spine is exceptional as an isolated lesion.

Dislocation

4. LUMBAR SPINE

The lumbar spine is the most commonly injured part of the vertebral column, and the dorso-lumbar region is involved in more than 50 per cent of lumbar

injuries. A crush fracture of the vertebral body is the most frequent type of injury and this results in a wedging of the affected vertebra. Owing to the relatively large size of the vertebral bodies in this area, the upper surface of the body may be involved in a depressed fracture due to the inferior margin of the vertebra above being pushed into the upper surface of the body below. Sometimes a splitting of the anterior surface of the body occurs. Fractures of the same type may occur as a result of a fall on the heels from a height. Lateral forces may give rise to more complicated types of injury, frequently with lateral wedging. *Crush fracture*

The vertebral arch may be fractured as the result of a direct blow. In the lower lumbar region the laminae may be fractured with a forward displacement of the more proximal vertebra on the more distal vertebra, causing a traumatic spondylolisthesis (Fig. 317). Similarly, a congenital developmental defect of the lamina with or without trauma may give rise to this deformity.

FIG 317.—Spondylolisthesis due to congenital defect in the laminae

Fractures of the lumbar transverse processes are of frequent occurrence either as a complication of other injuries or as a separate lesion These fractures usually follow sudden muscular contraction of the quadratus lumborum and require sympathetic treatment, because there are frequently extensive soft tissue damage and much pain. *Fractures of transverse processes*

Treatment

(a) Crush fractures

The treatment of the acute crush fracture consists of reduction by hyperextension and the application of a well-moulded plaster jacket extending from the pubis to the manubrium sterni, posteriorly it is cut away to the level of the inferior angles of the scapulae. Exercises for post-vertebral muscles and general exercises for the limbs, chest and abdomen are commenced as soon as the plaster is dry and the patient settled in his new position. A complication which may arise in the early stages is abdominal distension, it can usually be relieved by cutting a window in the plaster over the upper abdomen, but if this, together with medicinal measures, is insufficient to relieve the symptoms, the plaster should be bivalved and the anterior half removed, the patient lying in the posterior shell until the symptoms subside, when a further jacket is applied. *Abdominal distension*

The plaster is retained for approximately 4 months and, on removal, exercises, both general and postural, are continued. At this stage exercises in a swimming-pool are particularly useful to regain both movement and muscle power. If the intervertebral joints are dislocated, manipulation by traction and lateral flexion may effect reduction, but this is not easy, and operative treatment is frequently required. At operation, after exposure of the facets, reduction can usually be completed by gentle manipulation with a bone lever. The articular facets, however, are large, and it is sometimes necessary to remove part of the more caudal articular facet to allow the upper anteriorly displaced facet to drop back into place.

Exposure of facets

(*b*) *Lateral wedge fractures*

Many lateral wedge fractures cannot be reduced, and in these cases the patients, after being kept in the recumbent position for a few days, commence prone-lying exercises for the back muscles and general exercises for the limbs, trunk and respiration. It is usually advisable to continue recumbency for 4–6 weeks, but that is dependent on the degree of bony and soft tissue injury.

(*c*) *Fractures of the transverse processes*

Fractures of the transverse processes are treated by the application of supporting adhesive strapping and by postural exercises. The most extensive injuries require fixation and a plaster jacket. If pain persists after 6 weeks, a local Novocain injection of the tender spot often gives relief.

Novocain

Spinal fusion

Spinal fusion should be reserved for cases with persistent back pain after other forms of treatment have been tried. When it is performed it is well to remember that arthritis tends to develop in one or two vertebrae above the lesion if anatomical reduction has not been perfect, and this area should be included in the region to be grafted.

5. CARE OF THE PATIENT WITH PARALYSIS

The patient with paraplegia complicating vertebral fractures presents many problems, but those confronting the surgeon most frequently are associated with nursing the patient, the prevention of trophic ulceration of insensitive areas, the prevention of contractures of the limbs and the treatment of the bladder (*see* Paralysis—Management of, Vol. 6, p. 445).

The patient is most easily nursed on a plaster bed which is lined with Sorbo rubber or felt to prevent pressure sores, and constructed so that the paralysed muscles lie in the relaxed position. The bed should be mounted on blocks to facilitate nursing. The care of the insensitive skin, particularly during the first few weeks, is always an anxiety. The spinous processes, the posterior superior iliac spines, the sacrum and the heels are particularly vulnerable, and it is usually advisable to turn the patient in a turning case for several hours daily to allow treatment to these parts and to relieve them from pressure for a time. After the first 12–14 days the skin becomes more resistant and pressure sores are less likely to occur.

Care of the skin

The bladder

The bladder also presents a problem. In cases of retention, if there are no signs of recovery from the paraplegia after 24 hours, during which time catheterization is permissible, a suprapubic cystostomy gives the most satisfactory results. The bladder should be washed out once daily with a mild antiseptic solution. Tidal drainage gives a good result in experienced hands

but requires constant skilled supervision. Its advocates maintain that a contracted bladder is avoided. Cystitis is controlled by penicillin or other appropriate chemotherapeutic agent. *Cystitis*

The earlier the patient is fitted with a posterior spinal support and calipers and commences his re-education in standing and walking, the shorter will be his rehabilitation period. Patients with paraplegia can usually commence re-educational treatment in 4–6 weeks after the injury, while the patient retains his optimistic outlook and his bones have not become decalcified and liable to fracture under minimal stress.

6. OSTEOARTHRITIS OF THE SPINE

In localized osteoarthritis of the spine which is painful, operative fusion of the affected area is sometimes necessary and very effective. It should not be done unless treatment by physiotherapy and the use of a brace have been tried, nor should it be done if recumbency fails to relieve the pain.

BIBLIOGRAPHY AND REFERENCES

Aird, I. (1949). *A Companion in Surgical Studies*, p. 310. Edinburgh; Livingstone
Barnes, R. (1948) *J. Bone Jt Surg.*, 30B, 234.
Butler, R. W. (1935). *Brit. J. Surg.*, 22, 738.
Crooks, F., and Birkett, A. N. (1944). *Brit. J. Surg.*, 31, 123, 252.
Ellis, V. H. (1946) *Proc. R. Soc. Med.*, 40, 19.
Girdlestone, G. R. (1940). *Tuberculosis of Bones and Joints*. London; Oxford University Press.
— (1949). *Ann. R. Coll. Surg. Engl.*, 4, 214
Herbert, J. J. (1948), *J. Bone Jt Surg*, 30A, 680.
Jefferson, G. (1948). *J. Bone Jt Surg.*, 30B, 232.
Jones, R., and Lovett, R. W. (1929). In *Orthopaedic Surgery*, 2nd ed. London; Humphrey Milford.
LeVay, D. (1948). *Proc. R. Soc. Med.*, 41, 850.
McKenzie, K. G, and Dewar, F. P. (1949). *J. Bone Jt Surg.*, 31B, 162.
Mercer, W. (1945). In *Orthopaedic Surgery*, 3rd ed., p. 629. London; Arnold
Nicoll, E. A. (1949). *J. Bone Jt Surg.*, 31B, 376.
Perkins, G. (1940). *Fractures*, p 67. London; Oxford University Press
Risser [illegible]
Sedc [illegible]
Smit [illegible]
27, 1.
Speed, J. S., and Smith, H. (1949) *Campbell's Operative Orthopaedics*, 2nd ed, 1451, pp. 1400. London; Kimpton
Steindler, A. (1929). *Diseases and Deformities of the Spine and Thorax* St Louis, Mosby.
— (1939). In *Textbook of Surgery*, p. 432. Ed. by F Christopher Philadelphia; Saunders.
— (1940). *Orthopaedic Operations*. Springfield, Ill.; Thomas.
Taylor, A. R., and Blackwood, W. (1948). *J. Bone Jt Surg.*, 30B, 245.
Watson-Jones, R. (1944). *Fractures and Joint Injuries*, p. 301. Edinburgh, Livingstone.
Wiles, P. (1949). *Essentials of Orthopaedics*, p. 85. London; Churchill.
Wilson, P. D. (1938) *Experiences in the Management of Fractures and Dislocations*. Philadelphia; Lippincott.

[References to other titles are given under Spinal Column in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 11, p. 302.]

SPINAL CORD

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1. DEFINITION

307.] *Consideration is here given to those diseases of the spinal cord, its membranes and nerve roots, which are primarily of interest to the surgeon* inasmuch as they are amenable to relief by surgical methods. (Diseases of the vertebral column are dealt with under the heading of Spinal Column, p. 539.) Thus an account of the demyelinating and degenerative diseases of the cord is omitted; although these diseases may be precisely classified and of much interest to the neurologist, they are outside the scope of surgical treatment and therefore of only remote or academic interest to the surgeon.

2. ANATOMY

The cord is flattened antero-posteriorly in the cervical region but is of approximately circular cross-section elsewhere. The cervical enlargement is of maximum girth at the level of the fifth and sixth cervical vertebra, the lumbar enlargement at the twelfth thoracic vertebra. In the adult the conus medullaris lies at the lower border of the first lumbar vertebra, but in foetal life the cord occupies the whole spinal canal, and at birth extends as low as the third lumbar body.

Because of the difference in length between the cord and the vertebral column there is, from the cervical to the lumbar region, an increasing discrepancy between the position of the segments in the cord and the vertebral bodies to which they are related For practical purposes this discrepancy may be regarded as 1 in the upper cervical, 2 in the lower cervical, 3 in the upper thoracic and 4 in the lower thoracic region. (Thus the tenth thoracic segment is related to the sixth thoracic vertebra.)

The spinal pia is thicker and stronger than is the corresponding investment of the brain. It is highly vascular except anteriorly, where it is thickened to form a glistening band (linea splendens) which is continuous below with the filum terminale. The arachnoid is filmy and avascular and is separated from the pia by the subarachnoid space, which contains cerebrospinal fluid. Small calcareous or bony plaques sometimes occur in the arachnoid. *Spinal pia* *Arachnoid*

The spinal dura is bluish in appearance, separated by an interval from the front of the neural arches and overlain here by a variable amount of white, sometimes yellowish (epidural) fat. *Spinal dura*

The ligamentum denticulatum attaches the sides of the cord to the dural tube and consists of from 20 to 22 triangular slips which lie between the anterior and posterior nerve roots. Each slip is attached by its apex to the dura midway between the openings in it for the passage of nerve roots. *Ligamentum denticulatum*

The chief vessels to be seen in the cord when exposed at operation are paired and rather tortuous veins which lie on its dorsal surface. In these the blood current is for the most part upwards, so that their congestion usually suggests that there is some compression at a higher level. The blood supply of the cord *Veins*

reaches it by way of the nerve roots but the radicular vessels vary in size different roots. The middle thoracic part of the cord has the poorest lo segmental circulation, and the largest radicular vessels, the arteria radicu magna and the vena radiculus magna, are found in the lumbar region. Ev

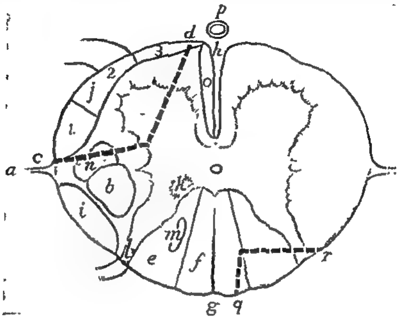

FIG 318.—Cross-section of cord showing position of main conducting tracts and the line of incision c–d for antero-lateral and q–r for dorsal chordotomy. (a) Attachment of dentate ligament; (b) crossed pyramidal tract, (e) fasciculus cuneatus (Burdach), (f) fasciculus gracilis (Goll), (g) septum posticum, (h) antero-median fissure; (i) direct cerebellar tract; (j) antero-lateral tract, 1, fibres from lower extremity; 2, from groin and abdomen, 3, from upper part of trunk; (k) Clarke's column; (l) Lissauer's tract, (m) comma tract, (n) rubro-spinal tract; (o) direct pyramidal tract, (p) anterior spinal artery.

effort must be made to preserve the radicular vessels (Suh and Alexander, 1939)

Tracts

The chief tracts in the cord are shown in Fig. 318. It is important to know their relative position and size when the operations of antero-lateral or dorsal chordotomy are performed.

3. COMPRESSION PARAPLEGIA

Aetiology

Paraplegia results from impaired conduction in the cord. Such impediment may be due to defective development, to disease such as one of the demyelinating or system diseases of the cord, or to pressure upon the conducting tracts which interferes with their function either directly or through their blood supply.

Brown-Séquard syndrome

Compression as the cause of paraplegia should be suspected whenever there is interference with spinal-cord function, but especially when the course of the disease is steadily progressive, and particularly if root pain is recognized without any neurological abnormality above that level. Examination may rarely reveal the presence of the Brown-Séquard syndrome at an early stage

of compression, but the following ancillary methods are required to establish the diagnosis.

(1) Skiagrams

Skiagrams of the spinal column may reveal the nature of the paraplegia by showing effects of pressure on the bone, for example, erosion by a vascular tumour of the backs of the vertebral bodies (Fig. 319) or a widening of the interpeduncular measurement. As a rule, however, skiagrams are not very helpful.

FIG 319 —X-ray appearances (lateral view) produced by a spinal haemangioma. The patient was a woman aged 35 years. Note the erosion of the backs of the vertebral bodies comparable with that produced on the fronts of the bodies by an aneurysm.

(2) Investigation of the subarachnoid space

(a) *Cerebrospinal fluid*

Froin's loculation syndrome

The presence of a complete spinal block is shown by the presence of Froin's loculation syndrome in the cerebrospinal fluid, which is yellow, clots spontaneously and contains a great excess of protein without

(a) (b) (c)

FIG. 320 —Myelograms of (a) spinal tumour; (b) herniated nuclear mass from intervertebral disc; (c) meningitis circumscripta serosa Note the lower edge of the opaque blob in each The medium was introduced by cisternal puncture in each case.

any increase in cellular content. The earliest sign is an *increase in protein* above the normal 25–40 milligrams per 100 cubic centimetres.

(b) The Queckenstedt phenomenon

Compression of the jugular bulbs at the root of the neck while the patient lies on his side with a manometer attached to a needle in the lumbar pond may show the presence of block as an absence or modification of the phenomenon. An important sign of a mild degree of compression is the failure of the pressure to return quickly to normal after it has been raised by jugular compression. *Failure to rise at all indicates a complete block.*

(3) Myelography

Myelography may be either cisternal or lumbar. Cisternal myelography is the more satisfactory. The introduction into the cisterna magna of radio-opaque viscid fluids heavier than cerebrospinal fluid, and subsequent x-ray *examination may not only reveal the presence but sometimes indicate the* nature of the block (Fig. 320). Lipiodol (40 per cent iodine in poppy-seed oil) was originally introduced by Sicard and Forestier of Paris in 1921, but substitutes such as Pantopaque or Myodil are more popular today. Reverse myelography from the lumbar route may show the lower limit of a space-occupying lesion.

Lipiodol

Reverse myelography

4. TUMOURS

(1) Neurinomas and meningiomas

Fortunately something like 80 per cent of spinal tumours are removable and rarely recur afterwards. If they are removed before the cord is irreparably damaged, recovery is excellent. Most of these tumours are intrathecal and extramedullary. The majority occur in the thoracic region and on the back (Fig. 321) or at the sides of the cord (Fig 322). They are either

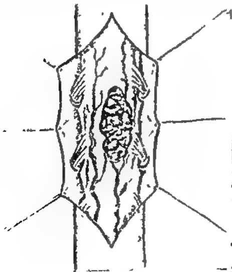

Fig. 321.—Dorsally placed spinal cord tumour exposed at operation.

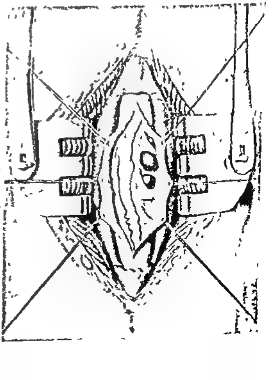

Fig. 322.—Appearance of laterally [illegible] seaman aged 23 years (*By courtesy of Brit. J. Surg*)

meningiomas (Fig. 323) arising from the membranes, the attached part of which, to prevent recurrence, should be excised with them, or neurin- *Sites* omas (nerve sheath tumours which have also been known as perineural

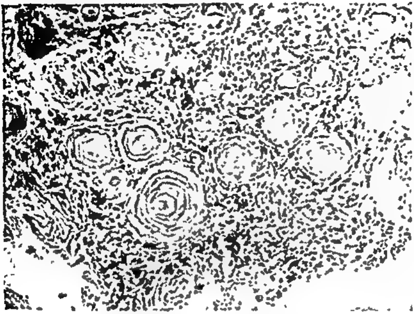

FIG. 323.—Typical microscopical appearance of spinal meningioma containing psammoma bodies.

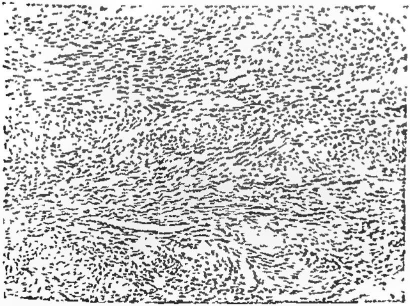

FIG. 324.—Typical microscopical appearance of spinal neurinoma

fibroblastomas, schwannomas, neurofibromas, neurilemmomas, and peripheral gliomas) arising from the nerve roots (Fig. 324).

The first spinal tumour to be successfully removed was almost certainly of this type. The operation was performed on June 9, 1887, by Sir Victor Horsley, at the National Hospital, Queen Square.

(2) Rarer tumours and other causes of compression

Lipomas may occur either outside or inside the dura, but are rare. Gliomas of different kinds may arise in the substance of the cord, the commonest being the ependymoma, but intramedullary tumours of all kinds are rare. In a series of 557 intraspinal neoplasms investigated by Rasmussen, Kernohan and Adson (1940) at the Mayo Clinic, only 64 (11·5 per cent) were intramedullary. Haemangiomas (Fig. 325) or vascular anomalies such as

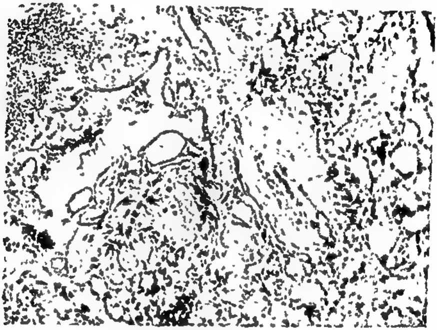

FIG. 325.—Same case as Fig. 319. Microscopical appearance of spinal haemangioma.

varicosities of the pial veins, may be a cause. The lower part of the cord is affected as a rule and, in the case of the varicose lesions, men are affected three times as often as are women, and there is occasionally an associated cutaneous naevus occupying a dermatome corresponding to the cord lesion (Wyburn-Mason, 1943).

Associated naevus

Extradural osteomas, and metastases, for example from thyroid gland, bronchus, testis, breast or kidney, may be a cause of the compression, and echinococcal (hydatid) cysts are an infrequent one. Another rare cause is *Paget's disease of bone. Tuberculous granulation tissue or a cold abscess* may be a cause, and occasionally pyogenic osteomyelitis gives rise to spinal compression (*see* p. 587).

5. SPINA BIFIDA

...ss forms

Although spina bifida may be met with in any part of the spinal column and is occasionally anterior in type when there is a defect in the vertebral body through which the meninges protrude, the great majority of these cases are posterior and occur in the lumbo-sacral region. Two varieties occur, gross forms and spina bifida occulta. The meningo-myelocele is the commonest

of the gross forms, others of which include the meningocele, the syringomyelocele, which is very rare, and the myelocele in which the central canal is unformed and the medullary groove opens out on the back. This variety is incompatible with post-natal life. Spina bifida occulta may be indicated by the presence of a dimple in the overlying skin, by a tuft of hair or a pad of fat, but in many cases is only revealed on x-ray examination. Many people have one or more defective neural arches but no disability therefrom. *Occult form*

(1) Indications for and contra-indications to operation

Operation is not indicated in all cases of spina bifida. There must be a reasonable prospect of repair without damaging the neural elements of the cord which may be spread out over the sac. The indications for operation are to prevent leakage or to improve function, occasionally also for cosmetic reasons The sac tends to leak cerebrospinal fluid and, if leakage is not prevented, infection is likely to occur and may lead to fatal meningitis. *Indications*

In spina bifida occulta, the presence of urinary incontinence, paresis of one or both lower limbs, deformity of the foot or trophic ulceration suggests that some benefit may be obtained from operation.

Contra-indications to operation are other gross developmental errors in the nervous system, such as paraplegia and hydrocephalus. *Contra-indications to operation*

(2) Time of operation

If it is decided to operate, little is gained by waiting and there is much to be said for performing the operation within a few hours of birth. Young babies stand the operation well and much is gained by the early correction of the deformity and thereby the consequent alleviation of parental distress. A case can also be made for the early restoration in the growing child of normal or as nearly normal conditions as possible, while the dangers of leakage and infection are removed by a successful operation.

(3) Spina bifida occulta

In spina bifida occulta there is usually no apparent deformity and rarely are there any symptoms. Skiagrams of the spine often reveal examples of defective neural arches which are completely innocuous. On the other hand, signs or symptoms of cord involvement (for example, trophic ulcers and urinary incontinence) sometimes appear at or about puberty or early adolescence. In some of these cases there is traction on the cord because of an anchorage of its terminal part to the skin or to the subcutaneous tissues by a fibrous band (membrana reuniens) and operation is indicated for division of this band so as to free the cord from an anchorage which interferes with its function. *Skiagrams*

In other cases of spina bifida occulta, operation may reveal a lipoma, a dermoid or rarely an intraspinal meningocele. It has been suggested by Ingraham (1944) and others that more of the questionable cases should be offered the benefit of exploration and this is the author's view also.

(4) The operation

When there is a well-developed sac this is best approached by transversely placed crescentic incisions made above and below it. Skin flaps are undercut and the sac is isolated from its surroundings and in whole or in part removed, *Incision*

care being taken to preserve any nerve elements which may be incorpora in it, by isolating and retaining the related part of the sac. The remair sac wall is infolded into the defect in the lamina and the soft parts are proximated, if necessary by undercutting the aponeurosis in order to do

No stitches are put in the sac wall but a touch with the endothermy nee may be necessary to seal a small vessel. If a meningeal defect remains is covered in by a thin sheet of fibrin film or Gelfoam.

Spina bifida occulta

All that is necessary in spina bifida occulta is to dissect carefully the herent cord free from its attachment to the overlying skin, at the same ti removing any lipoma, dermoid or abnormal tuft of hair which may present and making sure that any uniting band is completely divided.

6. LAMINECTOMY

(1) Indications

The indications for the operation of laminectomy are (a) to remove tumo or other space-occupying lesions causing compression of the cord; (b) decompress the cord in the case of irremovable and certain other lesions, opening up the spinal canal by removal of the neural arches; (c) to expo the cord for division of certain of its conducting tracts, for example, for rel of pain; (d) to remove foreign bodies; (e) to free the cord or its roots fro adhesive arachnoiditis, (f) to free the cord or its roots from compression extruded intervertebral material; and (g) for the division of nerve roots.

(2) Anaesthesia

Laminectomy may be performed under local infiltration analgesia or aft inducing spinal anaesthesia, but preference is for general inhalation anae thesia with an endotracheal tube. Induction with Pentothal Sodium follow by nitrous oxide, oxygen and chloroform anaesthesia has proved high satisfactory.

(3) The operation

(a) Position of patient

Whether the operation is to be performed on the cervical, thoracic or lumba part of the spine, it is best carried out with the patient fully prone, the hea supported on an outrigger and the chest kept clear of the table by shoulde supports (Fig. 326). If the laminectomy is to be performed on the thoraci or lumbar regions, the abdomen is kept clear of the table by means of sand bags placed under the anterior superior iliac spines (Fig 327). By this means pressure on the abdomen and consequent congestion of the spinal veins i avoided.

(b) Incision

Incision The incision is made along the line of the spinous processes. Curvec incisions and flap types of operation are to be avoided because the vascularity of the skin of the back is not as abundant as it is in some regions of the body, and the blood supply to the edges of the wound is maximal if this wound is a median longitudinal one.

Haemostasis Haemostats pick up any vessels in the subcutaneous tissue which may bleed. Skin cloths are attached to the wound edges and so used to shut off the skin

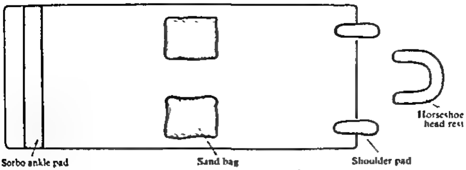

FIG. 326.—Plan of operation table arranged for laminectomy

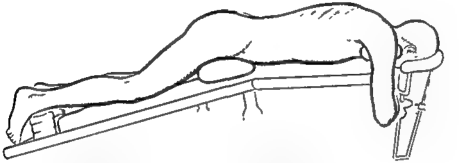

FIG. 327.—Position of patient for thoracic or lumbar laminectomy. For cervical laminectomy the position is very similar but with more flexion of the cervical spine.

FIG. 328 —Incision of skin and aponeurosis

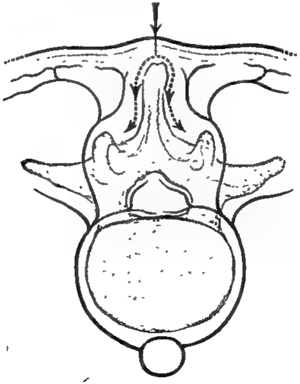

FIG. 329 —Diagram of incision and line of separation of muscle masses so as to avoid and preserve their blood supply.

of the back from the operation area. The aponeurosis is next divided in the line of the skin incision (Fig. 328) and, using scalpel, cutting endothermy and a broad-bladed osteotome, the erector spinae muscle mass is separated from the spinous processes and laminae on one side, the separation being close to

Separation of muscle mass

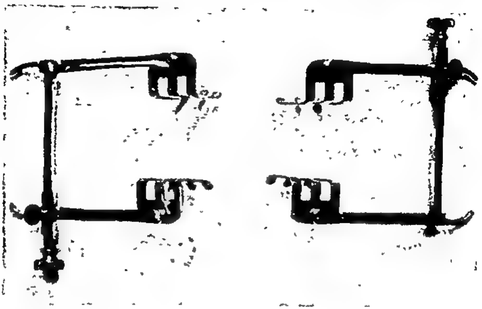

FIG 330.—Self-retaining laminectomy retractors Author's pattern.

the bone so as to avoid as far as possible the blood supply to the muscle masses (Fig. 329). As the muscle mass is separated gauze swabs are pressed into the gap produced by the separation. These swabs control bleeding and are left in position, while the muscle mass on the other side is likewise turned out of the post-vertebral groove by a similar subperiosteal manoeuvre, swabs being again used to control bleeding from the gap so formed.

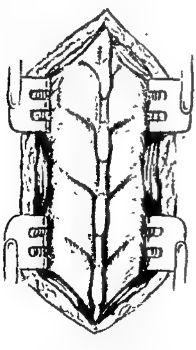

FIG. 331.—Exposure of spinous processes and laminae.

Retraction

The gauze packs are now withdrawn and replaced by laminectomy retractors (Fig. 330). These are opened to the required extent and are haemostatic as they exert pressure on the muscle masses which they retract (Fig. 331).

It should be emphasized that it is important to separate and handle the muscle masses gently so as to preserve them as far as is possible from injury. For this reason the incision should be adequate. A short incision with heavy retraction may be a cause of back

pain after operation because of muscle damage, and may be the reason for persistent post-operative backache in some cases of intervertebral disc lesion in which sciatica has been relieved by the removal of the disc through a *Backache*

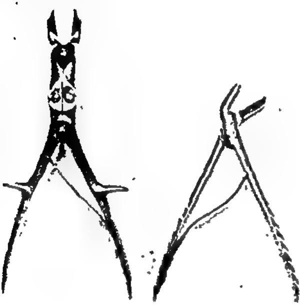

FIG. 332.—Instruments used for removing the spinous processes and laminae in the operation of laminectomy.

short and inadequate incision. Restricted exposure with the idea of producing short scars is usually bad surgery.

(c) *Removal of spinous processes and laminae*

The required number of spinous processes (usually 4 or 5) and laminae having now been exposed and cleared of any remnants of muscle by means of the endothermy needle, the spines are cut off at their bases with bone-cutting forceps and the laminae removed with nibbling forceps, of which those of either the Trotter or Hoffmann type are perhaps the best (Figs. 332 and 333). Bleeding from bone is arrested with Horsley's bone wax and from venous tributaries or small vessels in the muscle with a coagulating endothermy current applied to forceps. *Haemostasis*

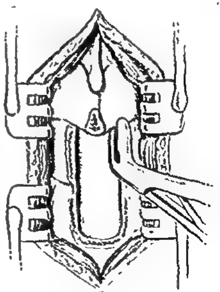

FIG. 333.—Removal of laminae with nibbling forceps

of the back from the operation area. The aponeurosis is next divided in the line of the skin incision (Fig. 328) and, using scalpel, cutting endothermy and a broad-bladed osteotome, the erector spinae muscle mass is separated from the spinous processes and laminae on one side, the separation being close to

Separation of muscle mass

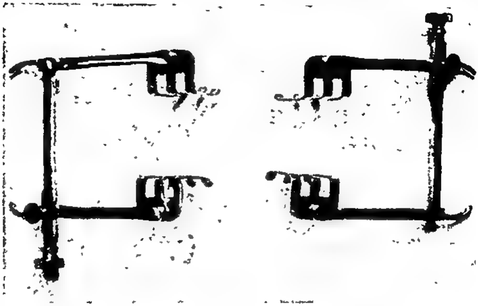

FIG 330—Self-retaining laminectomy retractors. Author's pattern.

the bone so as to avoid as far as possible the blood supply to the muscle masses (Fig. 329). As the muscle mass is separated gauze swabs are pressed into the gap produced by the separation. These swabs control bleeding and are left in position, while the muscle mass on the other side is likewise turned out of the post-vertebral groove by a similar subperiosteal manoeuvre, swabs being again used to control bleeding from the gap so formed.

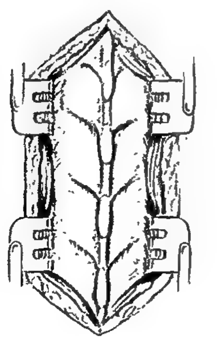

FIG. 331.—Exposure of spinous processes and laminae.

Retraction

The gauze packs are now withdrawn and replaced by laminectomy retractors (Fig. 330). These are opened to the required extent and are haemostatic as they exert pressure on the muscle masses which they retract (Fig. 331).

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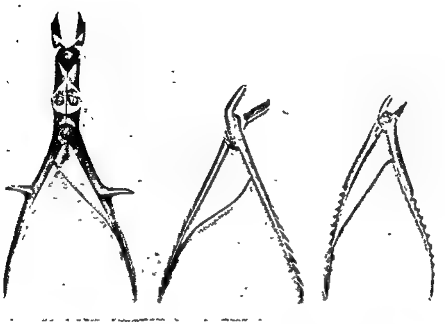


FIG 332.—Instruments used for removing the spinous processes and laminae in the operation of laminectomy

short and inadequate incision. Restricted exposure with the idea of producing short scars is usually bad surgery.

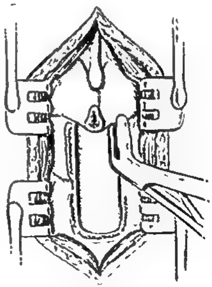


FIG 333.—Removal of laminae with nibbling forceps.

(c) *Removal of spinous processes and laminae*

The required number of spinous processes (usually 4 or 5) and laminae having now been exposed and cleared of any remnants of muscle by means of the endothermy needle, the spines are cut off at their bases with bone-cutting forceps and the laminae removed with nibbling forceps, of which those of either the Trotter or Hoffmann type are perhaps the best (Figs. 332 and 333). Bleeding from bone is arrested *Haemostasis* with Horsley's bone wax and from venous tributaries or small vessels in the muscle with a coagulating endothermy current applied to forceps.

(*d*) *The dura mater*

The layer of fat covering the dura is now exposed. This epidural fat varies very much in amount and there is sometimes so little of it as to make it almost unrecognizable; in other subjects it is well developed, firm and bluish-white in appearance, while in still others it is typical yellow fat as seen elsewhere in the body. This fat is cleaned off the exposed part of the theca and a series of fine sling or guy sutures is then introduced on either side of the central line along which it is to be opened (Figs. 334 and 335). If these

Guy sutures

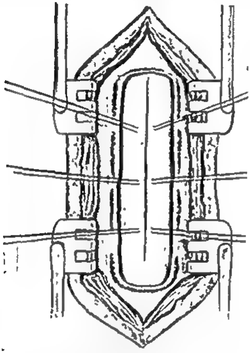


FIG. 334.—Exposure of dura. Sling or guy sutures have been introduced and the theca incised between them.

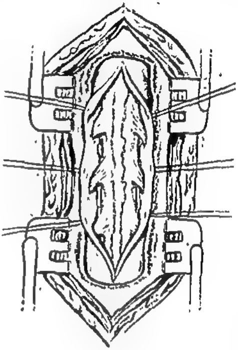


FIG. 335.—Dura opened and cord exposed.

sutures are carefully introduced so as just to penetrate the dura, and if slight traction is now exerted on them and the dura carefully opened along the central line, the arachnoid will be uninjured and, being transparent, will give a view of the cord bathed in cerebrospinal fluid, and of the tumour if this is extramedullary and on the back or sides of the cord. If the tumour is either intramedullary or entirely in front of the cord, the whole cord will be seen pushed backwards into the field.

(*e*) *Closure*

(i) *The dura mater.*—It is not essential, but in most cases desirable, to close the dura mater. This is effected with fine silk sutures and any defect which it has been necessary to produce in removing part of the membrane along with a meningioma may be repaired with a piece of pressed-out fibrin film or Gelfoam. If the tumour has proved to be massive and not removable, for example, a large intramedullary glioma, the dura is left open for decompression.

Fibrin foam

(ii) *The muscles.*—The muscles are approximated with several layers of interrupted catgut sutures, this absorbable material being used so as to interfere as little as possible with their subsequent function.

(iii) *Aponeurosis and skin.*—Interrupted fine silk sutures are used to approximate the edges of the dorsal aponeurosis, and interrupted nylon or waxed-silk fine sutures are used for the skin (Fig. 336) A dressing of dry gauze and *Dressing*

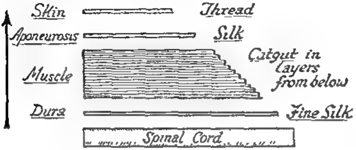


FIG. 336 —Diagram to show method of closure in layers

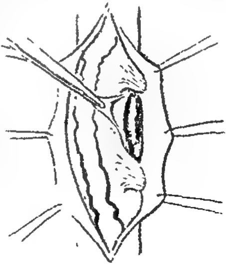
wool is applied and fixed in position with strapping and, except in the cervical region, with a "many-tail" bandage as well.

7. REMOVAL OF TUMOURS

(1) Extramedullary tumours

Extramedullary tumours are most often found on the back or sides of the cord and are so exposed when the dura over them has been opened. The covering arachnoid is dissected away from the tumour site and the tumour removed by working away from the cord from which it is elevated by an Adson or other form of dissector passed beneath it. If the tumour is adherent *Adson dissector* to a root, as is the neurinoma, the root will probably need to be sacrificed. Care must be taken to secure the vessels which accompany the root, with a touch of the coagulating endothermy

If the tumour is adherent to the dura, as is the meningioma, the piece of adherent dura should be cut out and removed along with the tumour so as to guard against recurrence from tumour cells which might otherwise be left adherent to the dura.



Traction on large tumours

FIG. 337 —Rotation of cord by means of detached slip of dentate ligament.

In the case of large tumours such as are sometimes found in the cauda equina, multiple threads passed through the tumour and then put under even tension and grasped with a forceps enable the surgeon to make gentle traction, and are helpful in the

dissection of the tumour from its surroundings. Only rarely is it n to break up a spinal tumour and remove it piecemeal.

(a) *Anterior tumours*

Mosquito forceps

Anterior tumours are brought into view by detaching a slip or slip dentate ligament from their dural attachments which are grasped by m artery forceps. The cord is then gently rotated by exerting slight trac the detached ligaments when the tumour is brought into view (Fi Care is taken, when freeing the tumour from its surroundings, not to the cord and particularly the anterior spinal artery which may overlie

(b) *Dumb-bell tumours*

Two stages of operation

Dumb-bell tumours have intradural and extradural parts connect pedicle which passes through an intervertebral foramen. As a rule t best dealt with in two stages, the first in which the cord compre relieved by removal of the intraspinal part, the second when the ex into the cervical or thoracic region is excised.

The first dumb-bell tumour to be successfully operated upon occu the practice of Mr. G. A. Wright of Manchester. The patient was a aged 38 who was tetrapleg August 21, 1888, a cervical ex of the tumour was remove then a Volkmann's spoon, intr through the enlarged interv foramen, was used to remo spinal part. The patient made recovery.

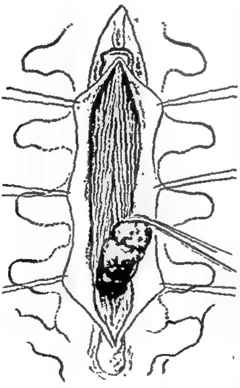


FIG 338.—Removal of cauda equina tumour.

(c) *Tumours of the cauda eq*

Clinical picture

Tumours of the cauda equi be massive chordomas or h giomas, but are more con small neurinomas or menin which may involve one or roots of the cauda and may p a typical clinical picture of s the pain of which may be i As a rule, the removal of tumours involves no special culty; care must be taken to damaging the cauda and to p its roots intact wherever possibl to extirpate the involved menin the case of the meningiomas 338).

The author has removed a chordoma from this region from a girl of 20 years of age. The t weighed 25·7 grammes and measured 8 3 centimetres in length an centimetres in width.

(2) Intramedullary tumours

If the tumour is intramedullary the cord is seen to be swollen in a fusiform manner. Gentle palpation will indicate whether the tumour is solid or cystic (syringomyelia may closely resemble an intramedullary tumour). If a cyst, this may be aspirated and opened through the median septum. If solid, the tumour may be exposed similarly and in some cases shelled out of its bed by blunt and gentle dissection with small pledgets of cotton-wool held in fine artery forceps or by the careful use of an Adson separator. If the tumour is firmly embedded, Elsberg's two-stage procedure may be adopted as follows. The tumour is exposed by the posterior longitudinal incision and the wound is closed. After a week or 10 days the wound is re-opened, when it may be found that partial extrusion of the tumour has occurred, and a complete or nearly complete removal may then be effected.

Syringomyelia

Elsberg's two-stage procedure

(3) Chordectomy

In hopelessly irremovable tumours which have destroyed the cord, section of the spinal cord above and below the tumour may enable complete removal to be undertaken, but this operation will be undertaken only when the destruction of the function of the cord is complete or is almost so. It has been recently performed at the Mayo Clinic, the cord being completely removed below its first thoracic segment (MacCarty and Kiefer, 1949).

8. OPERATIONS FOR OTHER CAUSES OF COMPRESSION PARAPLEGIA

(1) Tuberculosis

Paraplegia consequent upon compression of the cord by tuberculous granulation tissue or a cold abscess may require surgical treatment (*see* Spinal Column, p. 545).

(2) Intraspinal abscess

A pyogenic abscess is an occasional cause of compression paraplegia for which laminectomy and evacuation of the contents of the abscess are required. The nature and sensitivity of the organism to penicillin or to streptomycin is determined and appropriate chemotherapy, both general and local, is instituted.

Chemotherapy

(3) Hydatid cysts

Hydatid cysts occasionally compress the cord. The cysts arise in the vertebrae and are therefore extradural. In their evacuation care must be taken to prevent dissemination, and sterilization of their contents is effected therefore with either 2½ per cent formaldehyde or ether before attempting removal.

(4) Foreign bodies

Shell fragments or bullets, if lying near the cord, may call for removal because of an associated arachnoiditis. If there has been actual destruction of part of the cord by a foreign body, the outlook for recovery of function is not good.

Associated arachnoiditis

(5) Intervertebral disc lesions

Lesions of the intervertebral discs are referred to elsewhere (*see* Sciatica, p. 488). Either acute or chronic cord compression may be brought about by extrusion of nuclear material from an intervertebral disc, those discs most commonly affected being either in the lower lumbar or the lower cervical region. Removal of the extruded material may be either by an extradural operation or through both anterior and posterior aspects of the dural tube. In the cervical operation, the latter procedure is advisable for a central herniation of disc material, as the cord is under inspection and can be gently rotated and held aside.

Removal of extruded material

(6) Paget's disease of bone (osteitis deformans)

In Paget's disease of bone the cord may be compressed and paraplegia may result. The radiological appearances of the spine are characteristic and relief may follow operation.

An engineer, aged 61 years, one of the author's patients, recovered from his paraplegia and was able to return to work and was alive and well 9 years after operation.

9. OTHER OPERATIONS ON THE CORD

Chordotomy

Tract section is performed to relieve pain or to abolish the sense of position of a phantom limb. It has also been tried, but without any lasting success, for the relief of spasticity and to abolish the movements of paralysis agitans.

Phantom limb

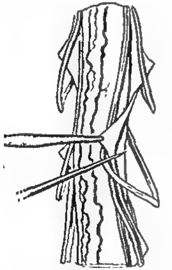


FIG. 339.—Antero-lateral chordotomy. The cord is rotated by gently drawing on a detached slip of the ligamentum denticulatum held in the beak of a mosquito forceps. The knife is entered in front of the pial attachment of the ligament and in front therefore of the crossed pyramidal tract.

(*a*) *Longitudinal chordotomy*

Longitudinal chordotomy, first performed in 1926 by Donald Armour, is not often practised today. The decussation of the pain fibres is divided just above the level of the lesion over a length of about an inch. Division of the median commissure at the eleventh and twelfth dorsal and first lumbar segments destroys the pain fibres from the lower limbs and pelvis. A blunt-pointed bistoury is used and care must be taken not to damage the anterior spinal artery.

Division of median commissure

(*b*) *Antero-lateral chordotomy*

First performed in 1911 by Edward Martin at the instigation of Spiller of Philadelphia, the operation of antero-lateral chordotomy has as its object division of the spino-thalamic tract which lies in the antero-lateral part of the cord (Fig. 318). Because the pain tract crosses obliquely over a course of several segments, the section must be made 4 or more segments above the upper level of the pain. The sites usually selected are the mid-thoracic or the upper cervical regions; at the thoracic site a bilateral

Sites

operation may be performed, but in the cervical region it is usually preferable to divide the tract on one side at one operation and that on the other at a later stage. The cord is exposed by laminectomy (usually it is sufficient to remove only 2 laminae) and the dura is opened. A slip of the dentate ligament is detached from its dural attachment and the cord gently rotated to bring its antero-lateral aspect into view (Fig 339). The tract is then divided, care being taken not to damage the anterior spinal artery at the point of emergence of the knife. By keeping entirely in front of the pial attachment of the dentate ligament, the crossed pyramidal tract is avoided.

(c) Dorsal chordotomy

Phantom limb

Dorsal chordotomy may be performed in cases of painful persistent phantom limb in which the painful condition is due to the distorted posture of the limb, such as a complaint of cramping, squeezing or twisting. Operations such as sympathectomy, rhizotomy, antero-lateral chordotomy, excision of the parietal cortex or even leucotomy have been carried out for such cases with varying degrees of success. Relief may be obtained by sectioning the dorsal column in the cord concerned with posture, either at the level of the second cervical segment in the case of an upper limb phantom or in the mid-thoracic region for one in the lower limb. For the upper limb, only the lateral two-thirds of the dorsal column is divided so as to avoid interfering with gait, but for a lower limb phantom the whole column is sectioned at the level of the sixth thoracic segment (Browder and Gallagher, 1948)

Other operations

10. POST-OPERATIVE CARE

Deep-breathing exercises are instituted as soon as recovery from the anaesthetic is complete, massage to recovering spastic limbs is to be avoided, but the patient is encouraged to try to move the limbs and to move about in bed. The dressing is left undisturbed until stitches are removed on the tenth day. After the wound has soundly healed, the patient is allowed up. If there has been retention of urine, care of the bladder will have been an important consideration throughout the course of treatment and until normal micturition is restored. In some cases a suprapubic cystostomy will have been performed, in others repeated catheterization or overflow incontinence will have developed by the time the patient has come under care. Whatever the method of dealing with the urinary retention, the greatest care must be taken to minimize infection in the urinary tract. Return of conduction in the cord may be considerably delayed by persistent urinary infection.

Care of the bladder

To prevent the formation or limit the development of pressure sores, frequent turning and changing of the position of the patient is necessary and skilled nursing attention is required.

Pressure sores

11. COMPLICATIONS

(1) Acute dilatation of the stomach

Acute dilatation of the stomach sometimes occurs, particularly after operations on the cervical cord; a quickening pulse and the vomiting of small amounts of dark material should make the surgeon suspicious. Washing out

Signs

of the stomach and change of position of the patient into the fully prone position, with the head downwards, may be necessary.

(2) Spasticity

Spasticity may be temporarily increased. Massage or reflex stimulation of any kind is to be avoided. As recovery of conduction occurs, the spasticity lessens, but in some cases peripheral nerve sections, for example, adductor neurotomy in scissor-leg deformity, may be helpful, the nerve being sectioned and sutured (Freeman and Heimburger, 1948).

(3) Cerebrospinal fluid fistula

Penicillin

Very occasionally leakage of cerebrospinal fluid may occur. Penicillin, 100,000 units, 3-hourly, should be given systemically when the patient is awake. The leakage usually ceases spontaneously as the wound heals, but if it is unduly persistent, re-suturing of the wound may be necessary.

(4) Pressure sores

Pressure sores (bedsores or decubitus ulcers) are to be avoided or limited in their extent by frequent changing of the position of the patient and attention to the skin. If they develop or progress despite careful nursing, conservative measures are advisable such as dusting with penicillin-sulphonamide powder With the return of sensation, healing occurs. (*See* Bedsores, Vol. 2, p. 65)

12. RESULTS

If benign intrathecal and extramedullary tumours are removed before cord compression has been so severe and so prolonged as to destroy conduction completely, the results of the removal are excellent. There can be few greater satisfactions in surgery than that which follows operation on a patient who has been stricken with the palsy and who recovers so completely as to be able to take up his bed and walk.

Grant (1948) has recently reported the results of 108 of these tumours occurring in patients between the ages of 10 and 78 years. Thirty of the patients were men, 78 were women. There were 6 post-operative deaths and 44 complete cures. Of 9 patients known to be dead, only 2 died of recurrence of their tumours.

Recurrences and relapses

The remote outlook for the patient with an intrathecal extramedullary tumour who makes a good early recovery following its removal is also good, particularly if the tumour is a neurinoma (Rogers, 1948b). Recurrences or late post-operative relapses very occasionally occur in the case of the meningiomas, a rare late complication of which is adhesive arachnoiditis at the operation site. This may occasionally give rise to root pain for which re-operation and division of the involved roots may be required.

BIBLIOGRAPHY AND REFERENCES

Armour, D (1927). *Lancet*, **1**, 423, 533, 691.
Browder, J , and Gallagher, J. P. (1948). *Ann. Surg.*, **128**, 456
Cohen, H., and Rogers, L. (1941) *Surgery of Modern Warfare*. Edinburgh; Livingstone.
Elsberg, C. A. (1925) *Tumors of the Spinal Cord*. London; Lewis.

Freeman, L. W., and Heimburger, R F. (1948) *J. Neurosurg.*, **5**, 556.
Gowers, W. R., and Horsley, V. (1888). *Med. Chir. Trans. Lond.*, **71**, 377.
Grant, F. C. (1948). *Ann Surg.*, **128**, 679.
Ingraham, F. D (1944) *Spina Bifida and Cranium Bifidum.* Cambridge, Mass., Harvard University Press.
Kennedy, A. M., and Rogers, L. (1928). *Lancet*, **1**, 225.
— — (1930) *Ibid*, **1**, 854.
MacCarty, C. S., and Kiefer, E. J. (1949) *Proc. Mayo Clin*, **24**, 108.
Rasmussen, T. B, Kernohan, J. W., and Adson, A. W (1940) *Ann Surg.*, **111**, 513
Rogers, L. (1931). *J. Coll. Surg. Aust.*, **3**, 311.
— (1935). *Lancet*, **1**, 187.
— (1943). In *Modern Operative Surgery*, 3rd ed. p 378. Ed. by G. G. Turner London, Cassell.
— (1944) *Med. Pr.*, **1**, 148.
— (1948a). *Ann. R. Coll. Surg. Engl*, **3**, 181.
— (1948b) *Aust N Z. J. Surg.*, **18**, 119.
Sicard, J. A., and Forestier, J. (1921). *Rev. neurol.*, **37**, 1264.
Spiller, W. G., and Martin, E. (1912). *J Amer. Med Ass.*, **63**, 1489.
Suh, T. H, and Alexander, L. (1939). *Arch Neurol Psychiat., Chicago*, **41**, 659
Wyburn-Mason, R. (1943) *The Vascular Abnormalities and Tumours of the Spinal Cord and Its Membranes.* London, Kimpton.

[References to other titles are given under Spinal Cord in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1939), Vol. 11, p. 302.]

NOTE.—Upon completion of the whole work an exhaustive analytical Index will be published in a separate volume. Each individual title in this volume has been separately indexed, and its subject-matter subdivided beneath that main title; additional references and cross-references beyond this, under the name of any particular subject, have been included. No attempt has been made to include references to subject-matter appearing in this volume which is dealt with fully in other volumes, although in one or two instances it has been possible to give the volume in which this subject is appearing.

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